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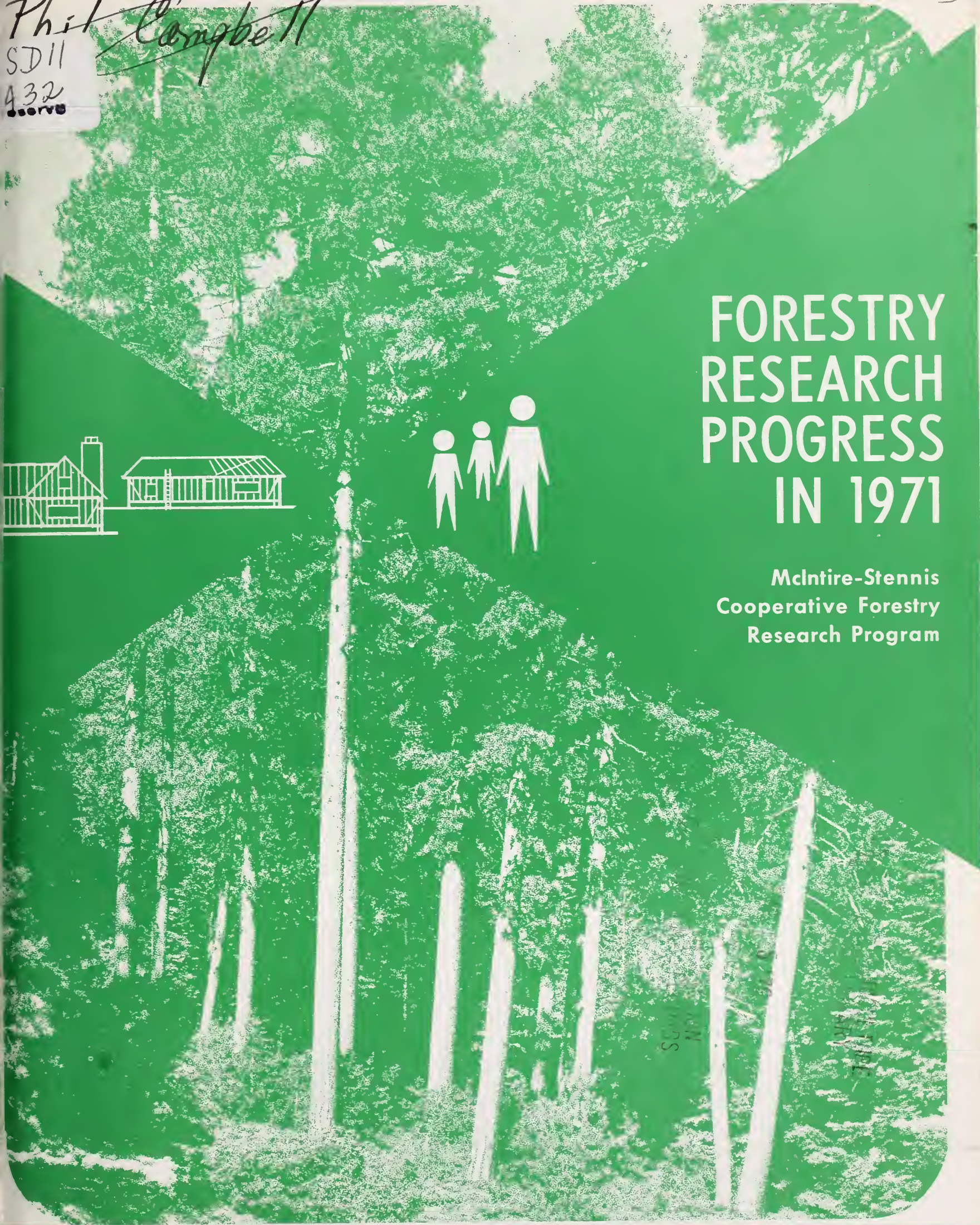
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FORESTRY RESEARCH PROGRESS IN 1971

McIntire-Stennis
Cooperative Forestry
Research Program



Preface

As in recent years, approximately one-fifth of the active McIntire-Stennis projects were selected to be featured in the 1971 Annual Report of Forestry Research. Each year the Current Research Information System (CRIS), from which these reports are obtained, becomes more valuable, not only as a mechanism for obtaining the reports presented herein, but also as a very valuable planning tool. A further attempt to use both the concepts of Research Problem Areas (RPA) and the Oxford System of Decimal Classification in Forestry was made in this report.

The printing costs of this report were borne by the Association of State College and University Forestry Research Organizations. Additional copies may be obtained by addressing a request to: Division of Information, Office of Management Services, U.S. Department of Agriculture, Washington, D C. 20250.

Contents

	<i>Page</i>
Introduction	1
CHAPTER 1. Factors of the Environment, Biology	3
Appraisal of Soil Resources (RPA 101)	3
Soil, Plant, Water, Nutrient Relationships (RPA 102)	5
Conservation and Efficient Use of Water (RPA 105)	7
Watershed Protection and Management (RPA 107)	7
Adaptation to Weather and Weather Modification (RPA 109)	12
Culture and Management of Forests and Timber-Related Crops (RPA 111a)	13
Genetics and Breeding of Forest Trees (RPA 301)	28
Fish and Other Marine Life, Fur-Bearing Animals, and Other Wildlife (RPA 904)	39
CHAPTER 2. Silviculture	46
Biology, Culture, and Management of Forests and Timber-Related Crops (RPA 111b)	46
Improvement of Range Resources (RPA 112)	54
Trees to Enhance Rural and Urban Environment (RPA 905)	56
CHAPTER 3. Forest Harvesting and Engineering	59
New and Improved Forest Engineering Systems (RPA 302)	59
CHAPTER 4. Forest Injuries and Protection	61
Control of Insects Affecting Forests (RPA 201)	61
Control of Diseases, Parasites, and Nematodes Affecting Forests (RPA 202)	68
CHAPTER 5. Forest Mensuration	75
Appraisal of Forest and Range Resources (RPA 110)	75
Biology, Culture, and Management of Forests and Timber-Related Crops (RPA 111c)	80
Remote Sensing (RPA 113)	82
CHAPTER 6. Forest Management	83
Economics of Timber Production (RPA 303)	83
CHAPTER 7. Marketing of Forest Products	86
Development of Markets and Efficient Marketing of Timber and Related Products (RPA 502)	86
Supply Demand and Price Analysis—Forest Products (RPA 513)	87

	<i>Page</i>
CHAPTER 8. Forest Products: Manufacturing and Utilization	89
Protection of Plants, Animals, and Man From Harmful Effects of Pollution (RPA 214)	89
New and Improved Forest Products (RPA 401)	90
Improvement of Grades and Standards of Forest Products (RPA 512)	107
Housing (RPA 801)	108
Alleviation of Soil, Water, and Air Pollution, and Disposal of Wastes (RPA 901)	109
CHAPTER 9. Forests and Forestry From the National Point of View	111
Alternative Uses of Land (RPA 104)	111
Outdoor Recreation (RPA 902)	111
Multiple Use Potential of Forest Land and Evaluation of Forestry Programs (RPA 903)	117
Improvement of Rural Community Institutions and Services (RPA 908)	119
APPENDIX I. Index of Projects by States	120
APPENDIX II. Summary of McIntire-Stennis Forestry Research Activity During 1971	134

FORESTRY RESEARCH PROGRESS IN 1971

McIntire-Stennis Cooperative Forestry Research Program

Introduction

The restoration, preservation, and enhancement of environmental quality have emerged as issues of high national priority. They are of the broadest magnitude, for environmental quality must encompass both the means by which man lives and the values which he receives from living. Man's environment begins with his most immediate surroundings, but stretches out to include the entire biosphere of which he is a part. The concerns of environmental quality must range from man's dwellings in the core of the inner city to the most remote wilderness areas.

Such problems are clearly interrelated. If urban environment is to be improved, building materials must be obtained from the natural environment. More lumber and plywood for more houses necessitate increased harvests from the forests. Alternative building materials have their own environmental consequences, including mining operations of all types, high energy requirements, and the depletion of nonrenewable resources. Thus, open space must be changed if urban space is to change.

Reciprocally, as urban areas change and expand, housing and related building construction move out into open space in widely varying patterns, with vacation homes broadcasting these impacts throughout the whole pattern of agricultural and wildland environments. Thus, the changes in urban space

which are enabled by changes in open space in turn lead directly to other changes in open space.

In studies of such complex interacting systems, forests and forestry have a central role. Forest lands represent one-third of the Nation's land area. The environmental effects of these forests on both air and water are of fundamental importance in the functioning of the biosphere. For an urbanized public, their ameliorative role through aesthetic and recreational effects is equally fundamental to the values of living. Simultaneously, these forests serve as a source of the Nation's only major industrial raw material which is readily renewable—a raw material which continues to provide the primary building material for housing and to serve in many other vital roles in the physical support of man's survival.

If man is to live in harmony with his forest and wildland environment, there must be a strong and systematic effort to increase the knowledge and understanding of these systems and to put such improved knowledge to use. The McIntire-Stennis Cooperative Forestry Research Act of 1962 is an important foundation of this effort. By providing for cooperation between the Federal Government and the land-grant colleges and other qualified institutions in the support, planning, and coordination of forestry research, the Act has enabled the development of a strong national research program in forestry with roots extending into each of the 50 States.

Compiled by Dr. Aubrey E. Wylie, Cooperative State Research Service, U.S. Department of Agriculture, Washington, D.C. 20250.

During 1971, 61 cooperating universities conducted forestry research under the aegis of the McIntire-Stennis Act. There were 521 projects active at the end of the year, involving 539 scientists and 471 graduate students.

This volume is a report of that research. It is a report of completed and on-going research. Here are the bits and pieces of knowledge which are being accumulated, validated, and evaluated. Here also are reports of progress in developing stronger and more reliable methods for identifying and measuring the interrelationships within the complex systems linking man and the forests.

These are the raw findings of research, often not yet fully tested and certainly not polished and placed in their settings. They have been grouped under various headings for the guidance of the reader, but they have not and cannot yet be placed in their full context.

One study analyzes the effects of suburban development on the adjoining and intermixed forest and wildland ecosystems. A second attempts to develop improved methods of sawing to enable the recovery of a greater volume of lumber from a given volume of logs. A third is involved with designing a computer model of a managed forest through which the effects of various cutting patterns can be simulated as a means of testing the effects of alternative management plans on the yield of timber. A fourth explores the interactions between deer and certain hardwood forest types, recognizing that deer may be considered as either a product of the forest management program or a threat to the establishment and growth of forest regeneration of desired species. The list goes on and on.

All this is implicit in the nature of forestry research in progress, and it is also a source of a special strength of a research program developed through universities. The individual research project must be concerned with the bits and pieces of knowledge and contributions to methodology. In this, the university

researcher is like any other research worker on the frontiers of knowledge. His role is to add his bit to the mosaic of knowledge available to man.

But the university researcher is also a teacher, and as a teacher his role is to synthesize and integrate knowledge and to place it in a context of relevance to man. This dual role gives a special perspective to the efforts of those engaged in the McIntire-Stennis program, enabling them to make a distinctive contribution to the total research effort related to forests and other wildland resources.

To facilitate the development and coordination of the program, the forestry researchers of the 61 participating State institutions have joined together in the Association of State College and University Forestry Research Organizations (ASCUFRO). The Federal aspects of the program are administered through the Cooperative State Research Service (CSRS) of the U.S. Department of Agriculture (USDA). This report on forestry research progress is a product of the cooperative efforts of CSRS and ASCUFRO.

The report is also representative of the close cooperation between CSRS and ASCUFRO in the planning and coordination of the total program. In these cooperative efforts, the Research Branch of the Forest Service, USDA, is an active partner. While each group has a distinctive role, all three groups share a common goal—the strongest total program that can be achieved with the available resources of funds, facilities, and scientists.

The ultimate test of the whole effort, of course, rests with the resource managers and interested members of the general public whose role it is to put these contributions to knowledge to use. This volume is published with the hope that it will be a useful step in making the knowledge available to them.

John A. Zivnuska
President, ASCUFRO

Chapter 1

FACTORS OF THE ENVIRONMENT, BIOLOGY

The forest represents a complex ecosystem, a renewable resource, from which man draws goods and services of a broad nature. The forester is charged with the responsibility of working within this ecosystem to provide man's needs, while protecting and maintaining the system's production potential for future generations.

Decisions concerning forest resources must be based on a knowledge of the relationships of the environment within this vegetative complex man calls a forest. This knowledge must be continually updated. The following reports describe current research intended to provide some of the essential knowledge relating to forest environment and growth.

APPRAISAL OF SOIL RESOURCES

Research Problem Area 101

Agricultural agencies make appraisals of the Nation's soil resources through soil classification and mapping the classified soil types. Research in support of soil mapping is concerned with identifying the parameters to be measured, including the correlation of soil map information with the use to be made of the data (for example, crop production, housing developments, zoning), and the development of effective and economic ways of reporting the results.

In recent years, the use of these findings has extended far beyond that made by farmers and ranchers. For example, sanitarians and home builders are using the information for judging the capacity of soils to absorb septic tank effluent; architects and developers use the information for site evaluation and foundation design; urban planners and other public officials use soil surveys for both general and operational planning of land use in rapidly expanding areas. Soil surveys can also be used to show soil characteristics such as susceptibility to frost heave or

slippage, depth to water table, depth to rock or other impermeable barriers, bearing strength, flood hazard, and soil erosion potential which affect suitability of a site for specific uses.

UNIVERSITY OF ALASKA, 270-0504

Nutrient cycles in selected interior of Alaska forest types.
K. VAN CLEVE

Field sampling has been completed in the black spruce biomass, nutrient status study, which is being conducted in cooperation with the U.S. Forest Service. Regression equations have been developed relating tree diameter to the mass of each major tree component. Analysis is underway to determine the chemical composition of overstory, shrub, moss, lichen, forest floor, and root samples.

Analysis of variance was conducted on first 2 years' data for height and diameter increment in complete factorial nitrogen, potassium, and phosphorus fertilizer study in 15-year aspen. Diameter and height growth showed similar responses to various combinations of fertilizer. Main effect response was due to the addition of nitrogen. Analysis of leaf tissue

samples collected on a 10-day basis during the growing season for N, P, K, Ca, Mg and total extractable carbohydrates was completed; these data will be subject to analysis of variance in the near future.

Expansion of the white spruce thinning study was carried out to include different intensities of thinning and different fertilizer regimes including macro- and micro-nutrients. These plots have been instrumented to measure soil moisture, soil temperature, atmospheric temperature, precipitation, snow depth, litter fall, and diameter increment.

UNIVERSITY OF ALASKA, 270-0545

Relationships among vegetation, ground ice, and disturbance on north-facing slopes in the Fairbanks area.
B. J. NEILAND

During September and early October 1970, 15 north-facing slopes were visited. These included most of the major vegetation types to be found on such slopes, and a good array of seismic lines, pioneer access roads, and cleared rights-of-way. Depth to ground ice (if under 5 feet) was surveyed in these different types and sites, and the vegetation, physical features, and other features were qualitatively described on 10 slopes. Preliminary descriptions were also made of the other five slopes which will be surveyed in more detail during summer 1971. The one transect that had been established prior to funding of the study was checked once snowfall had begun to record patterns of snow accumulation along it.

During the winter, some further survey for useful slopes was accomplished, but extraordinarily deep snows precluded much on-the-ground work. Some nonfield time was spent on study of data already accumulated to detect any possible patterns of correspondence of the parameters of interest. Other nonfield time was spent in contacting various U.S. and Canadian agencies to obtain any pertinent published or unpublished information, continuing the published literature search, and determining the transect layout on aerial photos.

The bulk of the field work for this project will be completed in the next field season.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION, 411

Phosphorus in lake sediments.

C. R. FRINK and W. A. NORVELL

Sorption of phosphorus by sediments from three lakes—Bantam, Zoar and Lillinonah—was measured in sealed containers without dilution or oxidation of sediment. Sorption of phosphorus by Bantam sediment is completed very rapidly, but the amount sorbed is only 40-60 percent of the P added. Sorption of P by Zoar and Lillinonah sediments is rapid initially, but then continues for 7 weeks or more at a slower rate. At least 80 percent of the added P is sorbed by these sediments. Bantam sediments contain roughly half the total P of sediment from the other lakes. However, an increase of only 5-10 percent in the total P in Bantam sediments will raise the equilibrium P concentration above that normally present in equilibrium with sediment from Zoar or Lillinonah. Sediment from Bantam thus appears to be much less effectively buffered with respect to changes in P concentration than sediment from the two more highly eutrophic lakes.

UNIVERSITY OF WASHINGTON, 17

Pedological investigation of forest soils.

F. C. UGOLINI

The character of vegetational changes as a function of time in the prairie-forest areas of the Puget Sound Lowland was determined using pollen analysis. X-ray diffraction analysis of the clay fractions of the prairie and forest soils shows that under both vegetation types there is a tendency for the chlorite and mica minerals found in the C horizons to weather to vermiculite in the surface horizons. Although there is greater accumulation of humus (humic and fulvic acids) in the prairie soil profiles, there are no consistent differences between the DTA patterns or the humic acid-fulvic acid ratios of these soils. Forest soils have consistently higher carbon-nitrogen ratios than prairie soils. The charcoal content of the prairie soil A1 horizons is high (2-3 percent) and adds considerably to the dark color and greater thickness of these horizons. The distribution patterns of free iron oxides show a greater tendency for podzolization to occur in forest soils. The organic matter in forest soils has a much greater capacity to complex free iron, whereas the organic matter of prairie soils has a

much greater capacity to complex free aluminum. The distribution of free manganese in these soils indicates that forest vegetation returns more manganese to the soil surface than does prairie vegetation.

ADDITIONAL PROJECTS

UNIVERSITY OF ILLINOIS, 55-0311

Soil-site relationships in northern Illinois.

H. W. FOX and R. F. FISHER, Jr.

PUBLICATIONS

VAN CLEVE, KEITH.

Effects of some intensive forest management practices in white spruce ecosystems in interior Alaska. In file in the Northern Environmental Symposium, edited by C. Slaughter, P. Barney, and G. Hansen. 1971.

VAN CLEVE, KEITH.

Energy and weight loss functions for decomposing foliage in birch and aspen forests in interior Alaska. Ecology 54:4. 1971.

VAN CLEVE, KEITH, and LORAIN L. NOONAN.

Physical and chemical properties of the forest floor in birch and aspen stands in interior Alaska. Soil Sci. Soc. American Proc., Vol. 35, 1971.

VAN CLEVE, KEITH, and DIANE SPRAGUE.

Respiration rates in the forest floor of birch and aspen stands in interior Alaska. Arctic and Alpine Research 3:1. 1971.

VAN CLEVE, KEITH, LESLIE A. VIERECK, and ROBERT L. SCHLENTNER.

Accumulation of nitrogen in alder ecosystems near Fairbanks, Alaska. Arctic and Alpine Research 3:2. 1971.

SOIL, PLANT, WATER, NUTRIENT RELATIONSHIPS

Research Problem Area 102

This problem area is concerned with the chemical and physical nature of interrelationships among soils, plants, water, and nutrients. The objective is to

maintain or restore the inherent production capability of soils.

UNIVERSITY OF KENTUCKY, 199

Edaphologically important physical and chemical properties of major forest soils in Kentucky.

R. L. BLEVINS and E. H. WHITE

Preliminary studies in eastern Kentucky indicate that deep colluvial soils such as Jefferson and Shelocta series make up a high percentage of the soils of this mountainous region. Previous research in areas with similar climate and landscape, combined with field experience in eastern Kentucky, indicate that direction of exposure is a land feature that is closely correlated to timber productivity as well as controlling the type of trees growing on the sites. Instrumentation was installed to continuously record the micro-climate conditions on a hot exposure slope (230°, azimuth) and a cool exposure slope (030°, azimuth) (fig. 1). Soils representative of these sites were described and sampled in the field and analyzed in the laboratory to determine their physical, chemical, and mineralogical properties. Soil moisture was measured monthly on the lower third, mid- and upper third slope of both the hot and cool slopes.



Figure 1. Mixed hardwood stand of yellow poplar, basswood, and maple on steep Shelocta silt loam, cool exposure slope. Weather house in foreground contains instruments to record continuously soil and air temperatures and relative humidity.

The cool slope consistently had higher relative humidity, cooler air and soil temperatures with less daily fluctuations, and about 2 inches more soil water (seasonal average) in upper 36 inches of the soil profile.

These soil and climatological factors are being measured to determine what factors, or combinations of factors, are responsible for higher timber production potential on the cool slopes. An understanding of these major factors will allow us to develop guidelines for better use and management of our land and timber resources.

LOUISIANA STATE UNIVERSITY, 1276

Rooting depth of mature southern pine trees as limited by soil characteristics. N. E. LINNARTZ

Weekly measurements of soil moisture were continued during 1971, but have not yet been studied or analyzed. Biweekly measurements of soil oxygen and depths to the water table have also been continued.

Soil oxygen measurements collected between April 4, 1970, and April 20, 1971, indicate that (1) O₂ content varied throughout the year, being lower in winter and highest in summer; (2) O₂ decreased with soil depth, (3) O₂ content was significantly affected by changes in soil moisture and fluctuations in the water table; (4) soil oxygen content was significantly related to capillary and noncapillary porosity but not to bulk density or soil texture; and (5) mature loblolly pines apparently are rather tolerant to low soil oxygen content during winter months and at depths below 4 feet.

UNIVERSITY OF WASHINGTON, 12

Fire on a forest soil. D. W. COLE

A series of models predicting transfer of Ca, Mg, K, and Na from an ash layer to the soil and between horizons of the soil profile have been developed for the second-growth Douglas-fir ecosystem at the Thompson Research Center. Rates of conversion of ash salts from oxides to carbonates have been measured.

ADDITIONAL PROJECTS

UNIVERSITY OF ARIZONA, 2016-4168-019

Nitrogen and carbon balances in forest and range ecosystems in Arizona. J. O. KLEMMEDSON

UNIVERSITY OF ARKANSAS, 610

Use alternatives on forest lands of Ozark upland region of north Arkansas.

H. A. HOLT and H. R. STOIN

UNIVERSITY OF FLORIDA, 1250

Water control for forest production.

W. L. PRITCHETT

UNIVERSITY OF ILLINOIS, 55-0308

Dynamics of soil microbiology and fertility during secondary succession. R. F. FISHER, JR.

UNIVERSITY OF MAINE, 5008

Fertilization of spruce-fir sites in Maine.

C. E. SCHOMAKER, R. A. STRUCHTEMEYER, and E. L. GIDDINGS

NEW YORK-CORNELL UNIVERSITY, 901

Effects of ectotrophic mycorrhizae on tree growth.

E. L. STONE and W. A. SINCLAIR

PENNSYLVANIA STATE UNIVERSITY, 1745

Revegetation of highly adverse sites created by coal mining.

P. J. HUTNIK, F. Y. BORDEN, and W. W. WARD

WEST VIRGINIA UNIVERSITY, 6

Microclimate modifications affecting reforestation of surface-mined lands.

R. LEE

PUBLICATIONS

FERGUSON, JAMES A.

How does forest-range conversion in Ozark uplands affect runoff. Arkansas Farm Res. 20(4):3. 1971.

GRIER, C. C., and D. W. COLE.

Influence of slash burning on ion transport in a forest soil. Northwest Sci. 45:100-106. 1971.

HENDERSON, G. S., and E. L. STONE

Growth of mycorrhizal Monterey pine supplied with phosphorus fixed on perlite. (In) C. T. Youngberg

and C. B. Davey, eds., *Tree Growth and Forest Soils*, Oregon State Univ. Press, Corvallis, pp. 171-180. 1970.

HU, SHIH-CHANG.

Seasonal and profile variations in oxygen content of forest soils under mature loblolly pine (Pinus taeda L.) stands. Ph.D. thesis, Louisiana State Univ., Baton Rouge, 115 pp. 1971.

HUTNIK, R. J., and D. N. THOMPSON.

Refuse bank reclamation studied for deep mines. Sci. in Agr. 18(3):12-13. 1971.

NICHOLAS, A. K., and R. J. HUTNIK.

Ectomycorrhizal establishment and seedling response on variously treated deep-mine coal refuse. Spec. Res. Rept. No. SR-89. Office of Coal Research Admin., Pennsylvania State Univ. 121 pp. 1971.

SINCLAIR, W. A.

Additive effects of different types of ectomycorrhizae on growth of Douglas-fir seedlings (Abst.). Phytopathology. Vol. 61, p. 911. 1971.

THOMPSON, D. N., and R. J. HUTNIK.

Environmental characteristics affecting plant growth on deep-mine coal refuse banks. Spec. Res. Rept. No. SR-88. Office of Coal Research Admin., Pennsylvania State Univ. 81 pp. 1971.

WHITE, E. H., W. L. PRITCHETT, and W. K. ROBERTSON.

Slash pine root biomass and nutrient concentrations. IUFRO XV Congress, Gainesville, Fla., Sec. 25:165-176. 1971.

CONSERVATION AND EFFICIENT USE OF WATER

Research Problem Area 105

Virtually all of the Nation's water supply arrives as precipitation on the land. Seventy percent of this supply is lost through evaporation and transpiration. The remaining 30 percent is subject to increasing competition among agricultural, industrial, and domestic users. Increased efficiency in collecting, storing, conveying, using, and reusing available supplies becomes essential.

UNIVERSITY OF RHODE ISLAND, 954

Evapotranspiration losses as related to site and vegetation differences. J. BROWN and W. GOULD

Various aspects of the water budget of Rhode Island forests are being studied and canopy interception studies in mixed-oak stands have been completed. Interception was found to be independent of age class in even-aged stands for stands up to 60 years old. Seasonal differences were not great. Crowns intercepted 12.8 and 10.1 percent of total rainfall for the growing and dormant seasons, respectively. Oak litter characteristics were evaluated for spring and summer periods. Mean dry weight of litter was less than that reported in other hardwood studies, but saturation values and drying rates were similar to previously reported results. Analysis of an intensive study of soil moisture depletion in relation to position under white and scarlet oak canopies has been completed. Significant differences in moisture contents between species were found to occur at the 2- and 2.5-foot depths near tree trunks. Differences were attributed to greater rooting intensities near scarlet oaks. Similarly, seasonal water losses considering inputs of net rainfall for locations near trunks were greater for scarlet oaks; losses averaged 24.2 inches for scarlet oaks and 16.3 inches for white oaks. Studies are continuing on water use between different vegetation types. Intensive sampling of white pine and oak types was conducted with 21 new soil moisture access tubes installed to depths of 8 feet.

PUBLICATIONS

BOURN, T. G.

Soil moisture distribution patterns in a Rhode Island mixed-oak forest. M.S. thesis, University of Rhode Island. 88 pp. 1970.

BOURN, T. G., and J. H. BROWN, JR.

Mixed-oak forest floor: Some characteristics. University of Rhode Island Agr. Expt. Stat. Bull. 407. 10 pp. 1971.

WATERSHED PROTECTION AND MANAGEMENT

Research Problem Area 107

Nearly 12,000 agricultural and forested watersheds in the country are in the size category commonly

encompassed in developments under the Watershed Protection and Flood Prevention Act, the Small Reclamation Projects Act, and similar programs. These watersheds include the cropland of the United States as well as the range and forest lands. Many of the watersheds need one or more of the following flood prevention systems: sediment control, wind and water erosion control, and improved management for water yield and quality.

Erosion control is needed to protect the productive capacity of the land. Sediment control is needed to prevent unwanted deposition of eroded material in reservoirs, harbors, stream channels, streets and highways, or on floodplain lands. Sediment in streams damages recreational values and must be removed from domestic and industrial water supplies.

UNIVERSITY OF CALIFORNIA, 2751

Impact of urbanization on natural ecosystems in the coastal ranges of California. J. R. McBRIDE

The objective of this project is to determine the impact of urbanization on the hydrologic, climatic, and biotic characteristics of forest and other natural ecosystems in the coastal ranges of California. The primary approach in achieving this objective is to directly observe and measure urbanization impact on a watershed. Three stream-gaging stations, a series of microclimate stations, and representative permanent vegetation plots are being established in a watershed which will be subdivided in the near future. The study will follow changes in annual water yield, flood peaks, air temperature, evaporative stress, species composition, and density of vegetation types during the urbanization process. The data collected will be used to develop models to predict changes in water yield, flood peaks, and microclimate associated with future urbanization in the central coastal ranges of California. Information from the vegetation plots will be useful in developing management plans for urban greenbelts.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION, 415

Waste water renovation potential of forest soils predicted by their chemical and physical properties.

D. E. HILL and C. R. FRINK

To determine the waste water renovation potential of six diverse Connecticut soils, 1 inch of a synthetic sewage effluent was applied semiweekly for 2 years to undisturbed cores 12 inches in diameter and 36 inches deep. After 2 years, chemical analysis of the leachate revealed that all P was removed from the effluent in the A horizon of all acid soils, probably by formation of a complex gel with Fe, Al, and Si. Calcium and Mg, which were removed up to 75 percent in all acid soils, may also be tied up in the complex gel. All loamy soils removed up to 85 percent K but only 10 percent Na. Up to 90 percent S was removed for 6 months in acid soils, but after 2 years all S added passed through the columns. Nitrate and Cl passed through the columns from the start. Removal of NO₃ can be assisted by forest vegetation or farm crops. Estimates of total cation exchange in the columns and the amount of cations sorbed during 2 years indicate that the longevity of the cores will vary between 10 and 13 years. Predictions of waste water renovation potential must consider not only the soil's capacity to remove potential polluting nutrients but also the pattern of movement of the nutrient-rich effluent through the soil. A study of layered soils with fine textures overlaying coarse textures verified the development of "wetting fingers" predicted at the interface of the two textures, permitting deep penetration of effluent with only small volumes applied (fig. 2). This will affect application rates of effluent on such soils.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION, 408

Conserving soil moisture with a stomata-closing chemical. P. E. WAGGONER

The loss of water and the possible reduction of this loss by partial closure of the microscopic pores, or stomata, in the foliage were investigated for 5 years in two red pine plantations in eastern Connecticut. Variations in stomatal resistance, water potential in the foliage, bole diameter, and stomatal resistance were measured. The disappearance of soil water, mostly via evaporation, equaled insolation and also evaporation from an open pan.

Spraying with phenylmercuric acetate doubled stomatal resistance in needles present during the springtime spray; later spraying scarcely affected



Figure 2. Wetting fingers at the interface of fine and coarse textures of soil appear as predicted.

stomata in new needles. Growth was unaffected in the first year, but decreased later. After 3 years of spraying, the foliage was decreased. Before defoliation, however, the change in stomatal resistance reduced the drying of foliage and shrinkage of the bole. It retarded the loss of soil water well within that predicted from a comprehensive model of energy and water exchange. The late removal of about a third of the foliage also decreased evaporation. Thus, a partial closure of stomata without destruction of vegetation altered the energy balance and conserved water. Over winter, this yielded about 25 mm extra water.

UNIVERSITY OF MISSOURI, 163

Forest hydrology of small Karst watersheds in the Missouri Ozarks. O. D. SETTERGREN

Analysis of hydrometeorological data from the central weather station and four forested headwater watersheds at University Forest has been completed. Calibration is continuing on the experimental

watersheds prior to treatment. Results of a study of the water balance of one of these small drainages indicate that during 1969, 8.36 inches of a total annual precipitation of 37.48 inches were lost through deep seepage to the Karst network. The greatest portion of the seepage occurred during the winter months when soil moisture storage was at a maximum. Management of the cover on these headwater catchments will affect the balance between local streamflow and deep seepage contributions to distant springflow along some of the region's major rivers. Electrical power has been provided at all watershed gauging stations (fig. 3) to insure against periodic failures of the electronic data recorders and to allow for a more dependable winterizing protection system of the controls and instruments. Plots are being installed at Bennett Spring State Park to investigate the effects of sewage effluent irrigation on the early seedling survival and growth of eight species. Water quality will be monitored to a depth of 4 feet; also, soil moisture levels will be inventoried. Perma plots are being established in the adjacent irrigated oak-hickory forest to detect long-term changes in the native woodlands.

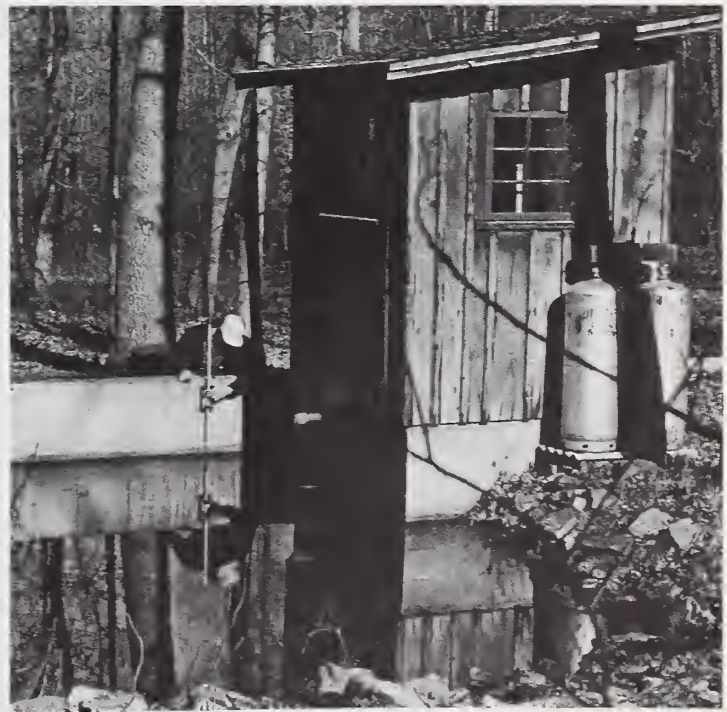


Figure 3. Gauging station used to measure the runoff component of the water balance of a small forested watershed in southeast Missouri.

**NEW YORK—STATE COLLEGE OF FORESTRY
AT SYRACUSE UNIVERSITY, 107—0—6**

Watershed model studies.

PETER BLACK

The primary objective of this project was to ascertain the effect of selected watershed characteristics on hydrograph parameters under a rainfall simulator so as to more accurately assess the effects of soil and vegetative manipulation on streamflow (fig. 4). Geomorphic and storm characteristics studies include watershed shape, size, slope, drainage pattern, and soil depth, and rainfall intensity, duration, and direction of storm movement.

Eleven iconic models have been constructed so that they vary and isolate the factors listed for comparative testing under replicable conditions. Testing has been done to discover empirical expression relating watershed characteristics and runoff behavior rather than for the purpose of verifying mathematical models.

The major facility has been constructed, calibrated, and tested, and models have been built and subjected to primary test runs under the stated objectives. Additional studies are planned to pursue questions raised during the initial phases and to investigate new recognized problems.

ADDITIONAL PROJECTS

UNIVERSITY OF ARIZONA, 2016—4168—017

Snow water yield from conifer forest.

D. B. THORUD and P. F. FFOLLIOTT

COLORADO STATE UNIVERSITY, 321

Water yields from shallow mountain soils in relation to forest cover.

E. W. MOGREN and H. L. TELLER

UNIVERSITY OF KENTUCKY, 603

Effects of man's use on forested watershed ecosystems.

E. H. WHITE and D. D. HOOK



Figure 4. Rainfall simulator for the Watershed Model Studies Project, State University College of Forestry, Syracuse, N. Y.

UNIVERSITY OF MASSACHUSETTS, 2

Evapo-transpiration, runoff, storage, and drainage characteristics of water from forest soils.

D. L. MADER and W. P. MacCONNELL

UNIVERSITY OF NEVADA, 675

Water retention and movement in snowpacks on the east slopes of the Sierra Nevada.

M. B. SULAHRIA and C. M. SKAU

PENNSYLVANIA STATE UNIVERSITY, 1495

Forest cover and timber harvesting methods related to streamflow.

W. E. SOPPER, R. E. MELTON, and
P. W. FLETCHER

UTAH STATE UNIVERSITY, 777

Water balances in intermountain stands of Englemann spruce-subalpine fir.

G. E. HART

UTAH STATE UNIVERSITY, 780

Root distribution and soil moisture depletion in three clones of Gambel oak.

J. D. SCHULTZ

WASHINGTON STATE UNIVERSITY, 16

Elevation-frequency analysis of cloud-engulfed forests in mountains.

D. R. SATTERLUND

WASHINGTON STATE UNIVERSITY, 1925

Ecologic characteristics of elk sedge (Carex Geyeri Boott.) for erosion control.

B. F. ROCHE, JR.

UNIVERSITY OF WASHINGTON, 20

Quantity measurement of snow-melt water as related to runoff.

D. D. WOOLDRIDGE and S. P. GESSEL

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ADAPTATION TO WEATHER AND WEATHER MODIFICATION

Research Problem Area 109

The future holds many possibilities for changes in weather and climate ranging from dramatic major

changes to microenvironmental changes around plants and animals. Research in agriculture has three tasks: (1) Characterize existing climatic patterns and propose more effective ways of adjusting to these patterns; (2) specify modifications that are clearly desirable to farm and forest; and (3) learn how modifications proposed by others will affect agriculture or natural ecology.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION, NEW HAVEN, 403

Mathematical simulators of the effect of environment on forests and forests on microenvironment.

P. E. WAGGONER and J. Y. PARLANGE

After the discovery that ozone intake is controlled by stomata and that the ozone concentration is reduced to 0 just below the stomata, mathematical simulators were devised for the cleansing of air within a stand of plants overlain by a constant pollutant cloud and also for the cleansing of the cloud as it moves over a forest. The calculated decrease in concentration at the top of a canopy as the air moves over the canopy is from 150 to only 30 ppb ozone in 8 hours. This resembles a decrease actually observed as air drifts from Los Angeles for a period of 8 hours. When a constant ozone concentration is maintained at the top of the stand, the calculated decrease in ozone concentration near the ground is about one-third if a negligible quantity of ozone is absorbed by the soil. Observations verified that the ozone concentration decreases considerably within a stand of plants. Further, the stillness of the air near the ground and an absorption of ozone by the ground causes an even greater decrease in ozone in the vicinity of the soil. Factors that encourage a large decrease in ozone concentration within the canopy are the following: A large leaf area with open stomata, slow ventilation, long stems, and a soil capable of reducing ozone.

ADDITIONAL PROJECT

UNIVERSITY OF WASHINGTON, 21

A coniferous ecosystem.

D. W. COLE

PUBLICATIONS

WAGGONER, P. E.

Plants and polluted air. BioScience 21:455-459. 1971.

CULTURE AND MANAGEMENT OF FORESTS AND TIMBER-RELATED CROPS

Research Problem Area 111a

Culture and management are directed at producing adequate supplies at reasonable cost, by methods that harmonize with other forest uses. For the 40 important commercial timber types in the United States, it is necessary to develop techniques for intensive culture on the most accessible and productive sites; and methods for combining timber culture with other uses on the remaining sites. The major job is to find out how to convert wild forests to managed forests of better species, higher quality, and faster growth in the shortest time and at least cost. Each type, including Christmas trees, has distinctive silvicultural characteristics. Research devises improved cultural techniques for the more than 130 commercial timber species, and better methods for forecasting growth and quality changes in relation to management practices, thus providing the basis for selection of economic alternatives.

UNIVERSITY OF FLORIDA, 1130

Correlation of soil survey information with tree growth. C. M. KAUFMAN and W. L. PRITCHETT

Height and diameter measurements of five trees were taken on each of about 1,300 plots for which detailed soil data on profile, physical, and chemical characteristics were also obtained. Most of the plots were in slash and longleaf pine, but a limited number of sand pine plots were also included.

Sorting of plot data by species and soil series showed site quality variation of 20 feet or more for many series. Following reexamination of the data, particularly reclassification into the seventh approximation from the former system, about three-fourths of the cards had to be repunched. A further check for precision now is being made following sorting of the data by soil series.

Processing of the data will be continued to develop site index information by soil series for slash, longleaf, and sand pine for both planted and natural stands.

UNIVERSITY OF HAWAII, 674-F

Exploratory studies on the physiological ecology of tropical forest communities and species.

R. A. GAY and D. MUELLER-DOMBOIS

The reanalysis of Hatheway's seven plots of native forest stands (initially investigated 20 years ago), the first phase of the Mokuleia dry forest study, has been completed. Almost all species recorded by Hatheway are still found in their respective plots. Except for plots 2 and 3, all abundant native species in each plot are regenerating and maintaining themselves. In plot 2, the regeneration of native *Canthium* is curtailed by a moth which kills the *Canthium* seeds. Nonnative *Schinus* trees have invaded and have also suppressed these *Canthium* trees. In plot 3, seedling establishment of native *Erythrina* trees is handicapped by the invasion of an introduced grass species, *Melinis minutiflora*, which covers the ground densely. New nonnative species invaded almost all plots, whereas new native species invaded plots located in or near the Mokuleia Forest Reserve only. If undisturbed, native forests can maintain themselves. However, some of the shade-tolerant introduced species seem to remain as minor components in these native forests. Among the native species, *Sapindus oahuensis* is able to invade the nonnative *Leucaena* stands (fig. 5), where *Sapindus* can become the dominant tree cover.



Figure 5. Exclusion of *Leucaena leucocephala* (dense stand in the background) from growing under the canopy of *Sapindus oahuensis*.

Sapindus seems to be one of the promising species to reclaim the dry lowland areas with native forest trees.

Field sampling for the community ordination study on the Island of Hawaii has been expanded to include all major geographic areas. Ordinations based on tree basal area and tree density of field data of previous summers show mathematical validity and ecological usefulness.

UNIVERSITY OF IDAHO, 14

Ecology of disjunct populations of red alder in Idaho.

F. D. JOHNSON

Two new forest communities were described for the first time. These forest associations, located along 100 miles of the canyon of the North Fork Clearwater River, Idaho, are both potential red alder sites. The western red cedar/maidenhair fern type is the more prevalent (fig. 6). Maidenhair and sword ferns dominate and the general appearance is similar to the coastal sword fern type common in western Washington and Oregon. Approximately 80,000 acres of this type exists, but 53,000 acres will be inundated under the pool behind Dworshak Dam. The second community is the western red cedar/male fern-spiny wood fern association. This community is rich in ferns and appears chiefly on well-watered alluvial terraces, stream bottoms, and old mass-gravity flow areas. Dominants include male fern, spiny wood fern, sword fern, and maidenhair fern. Several smaller ferns, such as oak fern and grape fern, are also common. The largest trees in the northern Rocky Mountains are in this community, including western red cedars up to 16½ feet in diameter. The existence of these old trees—estimated to be at least 1,500 to 2,000 years old—might well be attributed to the “fire-proof” nature of the fern-dominated understory.

When either of these two communities burns or is logged, red alder is likely to invade as a fire type. Fairly extensive stands of red alder of fire origin are found in the area on the western red cedar/maidenhair fern association. Red alder is not as common in the male fern-spiny wood fern association principally due to an apparent low incidence of fire. Red alder does invade after disturbance, but the disturbance is more likely to be landslides, floods, or the occasional windthrow of a mature conifer. Red

alder were sampled to compare inland with coastal growth as a parameter of productivity. Site indices were remarkably similar—the northern Rockies stands averaging only slightly below the coastal sites sampled during the development of the site index tables. Other seral trees include grand fir, Rocky Mountain Douglas-fir, western white pine, and northwestern paper birch in order of importance.

These “islands” of Pacific coastal vegetation in the northern Rockies continue to produce plants heretofore unknown in Idaho. Three new reports were added in 1971, making a total of nine species discovered since the inception of this project. It would appear that the remote and heretofore inaccessible lower canyons of northern Idaho are unique forest ecosystems.

SOUTHERN ILLINOIS UNIVERSITY, 64—R—004

Hardwood planting on upland old fields in southern Illinois.

C. A. BUDELSKY

This project has been terminated and no further active investigation of the material is anticipated. The area will be maintained for future reference because it has some value as a demonstration area. Since 1967, emphasis has been placed on determining the effect of cultivation and soil characteristics on the annual growth of the four tree species involved. Average total height was significantly greater (1 percent level) after five growing seasons when the competitive vegetation was reduced than in the noncultivated control. Average annual radial growth showed the same trend. No difference was found in mortality between the two treatments during the same time period. Soil moisture determinations during the growing season demonstrated that the influence of the herbaceous vegetation on the tree growth was due to competition for available soil moisture. Poor root development of trees in the noncultivated area undoubtedly intensified this condition. Studies of the soil profile characteristics resulted in a significant (1 percent level) direct relationship between tree growth and the depth of fragipan layer, regardless of cultivation condition.

UNIVERSITY OF MASSACHUSETTS, 9

Maple tree root initiation, development, and geotropic response.

B. F. WILSON



Figure 6. Seral western white pine (78 inches in diameter) in the newly described western red cedar/male fern association.

The first step in this project was to develop a technique for the ontogenetic analysis of long tree roots. Using this technique, the developmental history of a single root could be traced over a period of many years. Two major processes occurred in the roots analyzed: (1) Radial enlargement of root tips over time, a net increase each year superimposed on an annual cycle of diameter change; and (2) injury to root tips that resulted in branching of the woody

portion of the root system. Experimental injuries to root tips were investigated to establish the relationship between the extent of injury and the type of resulting branching. These experiments, plus other experimental and field observations, showed that there is apical dominance in large root tips that regulates the size of lateral root primordia formed. All these observations were combined to make a model for tree root system development. The

geotropic response of roots to varying soil compaction and soil obstacles was studied in the greenhouse. The roots tend to grow slightly downward in loose soil and nearly horizontal in compact soil. They have a positive geotropic response if oriented above the liminal angle but no negative response if oriented below the liminal angle.

MICHIGAN TECHNOLOGICAL UNIVERSITY, 2-3312

Determination of specific edaphic properties connected with forest soil-forest growth relationships.

STEPHEN G. SHETRON

Preliminary studies of differences in Continuous Forest Inventory gross merchantable cubic foot volume growth data for northern hardwoods show no statistical differences between calculated means for many of the major soil taxonomic units in the Upper Peninsula of Michigan. The variance in growth on each soil taxon overlaps one another. Thus, the predictability of northern hardwood growth is poor for forest soil survey and forest management purposes.

Four of the major soil taxons with similar calculated mean and variance in growth were selected. Continuous Forest Inventory plots were sampled according to the range in growth. Density of stocking was held to 100 square feet of basal area. The soils on each plot, previously described according to National Cooperative Soil Survey procedures, were sampled for physical and chemical properties. Also, landform and slope characteristics were collected for each plot. Automatic data processing will be employed to find meaningful functions for soil and landform effects on the established range in growth.

Results of the study should establish guidelines needed to refine soil taxons currently used for forest soil survey. Furthermore, these guidelines will indicate which soil and landform parameters are important in developing subjective ratings of soils for forest management purposes.

UNIVERSITY OF MICHIGAN, 12

Vessel length in angiosperm xylem.

R. ZAHNER

Research was conducted on the nature of vessel junctions in hickory. Several junctions were located

and carefully filmed by the Zimmermann shuttle method from microtome sections. Many characteristics of the junctions have been described and are planned for publication. This appears to be the first observation recorded of the nature of vessel junctions in ring porous wood.

Work was completed on another phase of the project, that is, relating vessel anatomy in red maple to the site on which the trees grow. Seventy-five trees from a full range of sites have been sampled, microtome sections prepared, and vessel characteristics analyzed.

UNIVERSITY OF MINNESOTA, 19-16

Environmental factors related to the failure of red pine reproduction. **B. A. BROWN and P. C. SMITH**

Within the constraints of the study, the following conclusions seem justified:

- (1) Red pine germination is best on shaded mineral soil. Exposed mineral soil sites are much less reliable, particularly when and where drought prevails. Burned litter, shaded or exposed, consistently produced fewer seedlings.
- (2) A mature pine overstory does not substantially reduce early survival and establishment of red pine seedlings, although it can inhibit certain growth phases.
- (3) The slow red pine seedling height growth during the first 2 years is not significantly affected by light reductions down to 25 percent of full light.
- (4) Competing vegetation was greatly curtailed on scarified seedbeds which were shaded to 30 percent of full light. On both burned litter and mineral soil sites, where light was reduced to only 55 percent, competing vegetation was most serious.
- (5) Insects were the chief cause of first-season mortality. Damage by insects was particularly serious on exposed scarified sites. Generally, the degree of damage was directly proportional to the amount of light present.

UNIVERSITY OF MONTANA, 210—1001

Soil moisture as a determinant of plants and animals in forest communities. **T. J. NIMLOS**

The role of soil moisture in the ecology of forest communities in west central Montana was examined. Seven study areas, on a gradient from very dry sites to very wet sites, were subjected to detailed, systematic observations over a period of 7 years. Weather, soil conditions, vegetation and faunal conditions, and similar parameters were measured, tabulated, and correlated. The study was conducted primarily on the Lubrecht Experimental Forest and, as part of the study, complete resource inventories were made on the forest. These included geologic and soil surveys; timber and forage inventories; mammal species, bird species, and invertebrate species lists; and complete records on weather and hydrologic characteristics.

UNIVERSITY OF MONTANA, 210—1801

Nutrient culture of western larch. **M. J. BEHAN**

Nitrogen, potassium, and phosphorus field fertilization trials were remeasured at four locations in lodgepole pine forests in western and central Montana. Each location consists of two blocks of four treatment plots, and each plot is 0.1 acre.

Diameter increments, height measurements, and foliar nitrogen, potassium, and phosphorus contents from over 500 western larch trees in 13 locations and fertilized with N, P, and K fertilizers in 1966 were obtained and analyzed for fertilizer response. Nitrogen responses were obtained in 10 plots and potassium responses in two plots. Increment responses in the treated plots ranged from an increase of 7 to 45 percent greater growth, depending upon location, than in the control plots. The responses were obtained despite 1968 being a drought year. A good correlation between fertilizer application, increment response, and foliar mineral content was obtained.

UNIVERSITY OF NEVADA, 676

Jeffrey pine regeneration using antitranspirants. **C. M. SKAU and G. A. AHLSTROM**

Evaluations of wildlands on the eastern side of the Sierra Nevada mountains indicate a critical need for

reforestation in this area, which is constantly plagued by wildfire, drought, erosion, invading brush, rodents, and sporadic seed crops. Much of the area has been denuded by fire or logging and has not yet reforested itself in over 100 years. Reforestation will enhance recreation, timber production, and watershed potentials while reducing flood and erosion hazards.

Artificial regeneration of Jeffrey pine, thus far, has completely failed. Standard 2-year-old nursery stock has had mortality rates of 90 percent or more, and direct seedling seems little better. Of 2,700 individually tagged endrin-coated seeds, 2,678 were consumed by rodents despite the application of 10 pounds per acre of poisoned grain. Of the 21 that germinated by May, not one survived the summer drought.

Antitranspirants are being evaluated as a means of reducing plant moisture requirements following planting. From more than 100 available antitranspirants, 15 impermeable layer types were selected on the basis of toxicity and longevity. These 15 were tested on 4-year-old Jeffrey pine seedlings which were instrumented for sap velocity measurements using heat transport techniques. The average sap velocity reduction after treatment was from 15 to 20 percent and lasted several weeks.

Color-infrared photography indicated there were no immediate or long-term toxic effects. Top growth was also unaffected. Infrared surface temperature measurements showed that the treatment raised needle temperatures by 2 to 3°C.

Field trials with 6-week-old seedlings, using two chemicals with various application rates and planting dates, have been set out. Initial results show that untreated seedlings survive somewhat better than treated seedlings. This result is tentatively attributed to inhibited shoot and root growth.

NEW JERSEY—RUTGERS STATE UNIVERSITY, 254

Factors affecting an allometric relation in trees. **B. B. STOUT**

In 1881, Greenhill developed a model for the height-diameter relationship in trees: $H=aD^{.66}$. Earlier work has shown that this expression, while a

good approximation for a wide range of diameters, does not fit as well as might be expected for all diameters. On the basis of samples of trees of the same species from similar sites covering a diameter range of 2-25 inches, the model tends to underpredict in the 4- to 12-inch range and overpredict at other diameters.

The sample of a range of diameters substitutes space for time, hence the reason for embarking on stem analyses. Early results indicate that other factors may be operating. Additional stem analyses will be made in a search for a pattern.

Related to the individual tree is the growth of the entire forest. A three-stage least squares solution to a system of equations is beginning to produce results. An iterative procedure is used. The coefficients of the fifth iteration are the point at which stabilization usually occurs. The coefficients are different from those obtained from a least squares solution for the individual species. The procedure appears to be removing some of the bias. Data on all species in a forest and measures of environmental variables are welcome since this work is continuing.

NEW YORK—CORNELL UNIVERSITY, 905

Effect of soil fertility on forest ecology and growth.

E. L. STONE

In 1968-70, a series of nitrogen rate trials in thinned second-growth hardwood stands were established to observe responses to increased fertility. These now await remeasurement.

Tests have been made of K and K Mg fertilization as a means of increasing survival and early growth of red and white pine seedlings on infertile sand plain soils surrounding the Adirondack Mountain area. An unexpected finding was that summer frosts were a major cause of mortality and apparently severe enough to override any notable influence that K might have on improved frost hardiness. Subsequent on-site temperature measurements (thermometers at 3 feet height; top-shielded only) yielded maxima of 85 to 100°F whereas minima reached 27 in July and 21 to 30 in August. The minimum reported by standard Weather Bureau statistics in the region was 31 on August 31. Mapping areas of complete mortality showed their association with dead-level

surfaces and unperceived depressions only a few inches deep, as well as in shallow drainage-ways recognizable as "frost-pockets." It appears that much of the early mortality of pine plantations formerly attributed to drought, spring frost, and unidentified causes is actually caused by out-of-season frosts. Clearly, planting success can be increased by recognition of high-hazard sites and planting of only Jack pine—the hardiest species available—on them.

A byproduct of nutrition research has been identification of arsenic toxicity as the cause of an unknown needle tip burn in conifer nurseries. These symptoms, suggesting those of nutrient deficiency, occurred on red pine in a State forest nursery and on hemlock ornamental stock in three commercial nurseries. In red pine, conspicuous tip burn symptoms were associated with contents of 8-12 ppm as in the needles. Fine roots contained up to 50 ppm, however, and were damaged to the point that most seedlings would not survive transplanting. The source of the arsenic is earlier use of arsenical insecticides and phytocides. Soil analyses now provide a means of identifying and avoiding toxic areas for species known to be susceptible.

OREGON STATE UNIVERSITY, 646

An ecological framework for forest land management in southwestern Oregon.

R. H. WARING

The study began with a survey across the southern tier of forested mountains from the coastal range to the Cascades. Within this zone, a region was defined based upon its distinctive flora and climate. Within this region, 29 sites were selected for intensive environmental measurements. These measurements included air, soil temperature, relative humidity, light, and soil fertility. An attempt was made to link the environment directly to various physiological responses by two widely distributed conifers, Douglas-fir and Shasta red fir. In these species, plant moisture stress, stomata response, cell division, and nutrient status were evaluated throughout the growing season. From these measurements, the environmental distribution of many plant species was quantitatively defined. On the basis of analyses of these distributions, sensitive species were selected to permit one to define environment of any potential forest site in the region. Associated species and relative growth, as well as particular problems

associated with such environments, were described. Through a study of light and growth responses by major conifers, the general successional development on various sites was clarified. A computer model was developed to integrate the classification scheme, permit identification of environments, and provide a listing of potential species composition.

OREGON STATE UNIVERSITY, 761

Mechanisms of secondary forest succession in western Oregon. M. NEWTON and W. W. CHILCOTE

Forest species occur in complex mixtures. The process of succession involves replacement of some species by others of greater persistence or adaptability to the local environment. An understanding of the processes by which organisms of the forest displace others is vital to development of minimum-disturbance practices which foresters can manipulate deliberately. This study has examined some features of plants that are both harmful and/or beneficial to associates, and has integrated measures of animal responses to the forest environment with regard to the way these animals influence succession of plants. Five major factors appear to be involved in the role of any given species in forest succession for the first decade after disturbance: (1) First and second derivatives of juvenile growth, (2) persistence in low light, (3) ability to reproduce in prevailing moisture regime, (4) ability to fix nitrogen and/or cycle mineral nutrients, and (5) palatability to animals. Low-disturbance manipulation techniques are now being developed to modify adaptability of undesirable species and to improve habitats for desired species. Selective application of such techniques has been demonstrated to control succession of species to meet the requirements of management objectives with minimum adverse ecological impact.

OREGON STATE UNIVERSITY, F882

Impact of herbicides on western Oregon forest ecosystems. M. NEWTON and W. S. OVERTON

Plant community structure has been described on old fields as the function of various herbicide treatment schedules over a 3-year period. Douglas-fir and grand fir have been introduced to observe their responses to voids vacated by damaged herbs. Both planted conifers and natural seedling Douglas-fir are increasing rapidly where associated herbs have been

controlled continuously. Stress in conifers is strongly related both to the amount and root distribution of invading herbs. Untreated herbs remain stable against both planted and natural conifers. Mechanisms of stability, and of coniferous responses to environments wherein these mechanisms have been interrupted, are the focus of a mathematical model now in preparation. A study has been concluded that provides strong evidence that minimum soil disturbance should be associated with vegetation control for both survival and growth optima. This suggests that herbicides are preferable to bulldozers for brush or weed control of comparable degree. A comprehensive model is being prepared which characterizes forests as dynamic systems of processes and compartments, in which the impact of herbicides is characterized in terms of effects on measurable rates and storages.

SOUTH CAROLINA-CLEMSON UNIVERSITY, 887

Phenolic compounds in the flower parts of pines.

R. M. ALLEN and A. T. SHEARIN

The phenolic compounds extracted from the male strobili of various pines were examined by paper chromatography to determine if the method would be of value for taxonomic purposes. In this preliminary study, results from the paper chromatographs of the extracts of the strobili indicate there were differences in the phenolic compounds that distinguished the three species of pine examined. However, the variability from tree to tree in kinds and amounts of compounds extracted from five putative natural hybrids did not permit any firm conclusion on their parentage.

Collections of male strobili were made from at least three trees each of *Pinus taeda*, *P. echinata*, and *P. rigida*, growing on the Clemson forest. In addition, collections were made from five putative natural hybrids found on the forest. The catkins from a given tree were blended in boiling water, which was then filtered, cooled, and extracted with ethyl acetate. The concentrated extract was chromatographed in two dimensions using a n-butanol:acetic acid:water (12:3:5) solvent in the first direction and a sodium formate:formic acid:water (10:1:200) solvent in the second. The chromatograms were developed with a

sulphanilic reagent, although in some instances a nitraniline reagent was helpful.

TEXAS AGRICULTURAL EXPERIMENT STATION, 1527

Silvical requirements for optimum growth of loblolly pine.
R. RHODES ROBERT

Annual precipitation in the east Texas piney woods varies from 40 to 60 inches. Prolonged summer droughts, however, are common across the entire region and soil water deficits (Thornthwaite) of 10 to 20 inches are not unusual. This portion of the study program reports on the relationship of periodic and annual diameter increment to precipitation and Thornthwaite's soil water deficit.

Study plots were established in four sawlog-size loblolly pine stands along a precipitation gradient from 40 to 48 inches. Weather observations at each site included daily precipitation, continuous temperature and relative humidity, and weekly open-pan evaporation. Diameter increments were measured at biweekly intervals with band-dendrometers (fig. 7). Measurements extended over a 4-year period. Thornthwaite daily water deficits were computed using Zahner's and Stage's computer program.

Soil water deficits over the 4-year period occurred only during the May–October period. In 2 years with



Figure 7. Diameter increments measurements were taken over a 4-year period in this pine-hardwood stand.

distinct dry periods, biweekly diameter increments (May–October) were significantly correlated with either periodic precipitation or soil water deficit. Predictive values were similar for both areas. During 2 wet years, correlation was poor with either variable as increments progressed uniformly throughout the observation period.

Annual diameter increment was best described by the annual soil water deficit. Yearly growth differences occurred primarily in the May–October period; growth conditions at this time are better related by soil water deficits than by precipitation alone. Annual soil water deficits appear to be a useful tool in growth comparison studies.

UNIVERSITY OF VERMONT, 18

A study to experimentally induce differentiation in tissue cultures from sugar maple trees.

M. MORSELLI

Anatomical differences observed between high and low sugar content maple trees suggest that genetical differences conceivably are responsible for the differences in production of sap from many sugarbushes.

Maple callus tissue clones, capable of doubling their growth in 2 weeks, have been developed from roots and stems of superior maple trees (fig. 8). These trees are superior because of both high sugar concentration and high yield of sap flow. This project is aimed at the induction of differentiation of the totipotent meristematic cells of the maple callus tissue. Since there is no sexual fusion involved, and we are dealing with cells having the chromosome number of the parent plant, genetically identical plantlets will eventually be grown *in vitro*.

Maple callus tissue cultures, which normally grow in a medium of known chemical composition, were exposed to treatments of selected hormones reported by other investigators to induce differentiation in tissue cultures of herbaceous and a few woody species. Since these treatments have not yet induced differentiation in maple tissue cultures, other factors, including environmental ones, may be involved—mainly enzymatic inhibition.

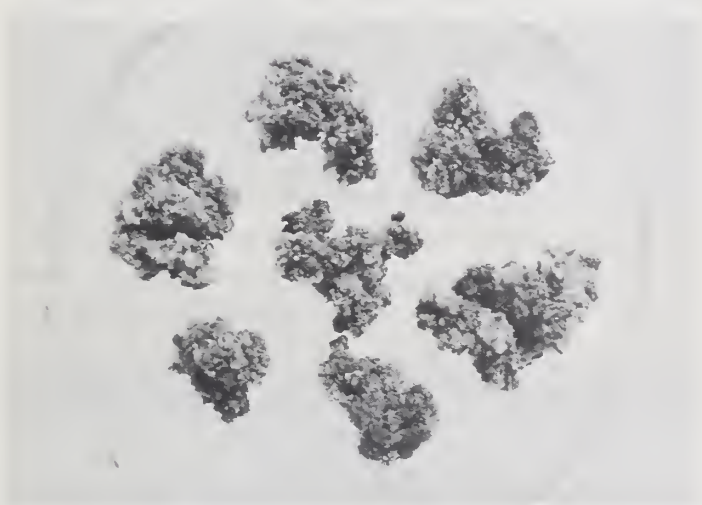


Figure 8. Callus tissue cultures from sugar maple. A—Root tissue. B—Stem tissue.

Hopefully, experiments with natural extracts of maple tissues, maple sap fractions, and synthetic chemicals will stimulate the *in vitro* development of roots and shoots from (1) callus cells, (2) adventitious and dormant buds, (3) terminal and lateral buds of sugar maple, and (4) stem internodes of defoliated, debarked, or intact sugar maple trees.

An investigation is also being made of the *in vitro* synthesis of lignin as an indicator of differentiation in the presence of selected lignin precursors. We are duplicating the natural variables to which the trees are exposed, such as light temperature, to study the effects of environmental factors at the cellular level.

VIRGINIA POLYTECHNIC INSTITUTE, 636125
Synthesis of ribonucleic acid and development of the ribosomal system.

R. E. ADAMS and L. B. BARNETT

Completed sucrose gradient analyses of female gametophyte rRNA's. Synthesis patterns during germination paralleled and thus substantiated earlier findings *via* direct RNA assay. Synthesis of rRNA peaks near the third day of germination, but continues through the tenth when more than 60 percent of total phosphorous and dry weight have disappeared and the female gametophyte is about to be shed.

The 5S RNA invariably developed higher specific activity than 1rRNA or hrRNA during long isotope incubations. Earlier work indicating increase in the 5S RNA peak relative to hrRNA or 1rRNA as germination progressed apparently was due to nuclease activity and did not reflect the *in vivo* condition.

Evidence for preformed mRNA in the dry female gametophyte was obtained from: (1) Imbibition studies in presence of actinomycin D, (2) studies of association of ribosomes and messenger following imbibition under anaerobic conditions, and (3) studies of effect of RNase on the ribosome dimer present in dry seeds.

VIRGINIA POLYTECHNIC INSTITUTE, 636174

Control of protein synthesis in germinating p. lambertiana. R. E. ADAMS and L. B. BARNETT

This project was undertaken to evaluate control mechanisms and variation of protein synthesis—essential for germination—in sugar pine (*Pinus lambertiana*) seeds. The research will increase understanding of the process and provide knowledge that could ultimately lead to more efficient use of tree seeds.

First, procedures were adapted for estimating protein synthesis in living seeds by measuring incorporation of radioactive amino acids into protein. Using these techniques, development of protein synthesis will be studied as dormancy is broken and germination takes place. Comparisons are also being made of the characteristics of nonliving, protein-synthesizing systems made up from portions of cells from either storage tissues or embryos from these seeds. The embryo system is more active than that of the storage tissue, apparently due to a difference in the component known as the pH 5 fraction. Attempts are

being made to determine the nature of this difference and whether it varies as dormancy is broken.

Sugar pine seed ribosomes, another component of the protein synthesizing system, have been characterized. They have a sedimentation coefficient of 78.2S and contain 41 percent RNA and 58 percent protein. The ribosomes contain three ribosomal RNA components of 28S, 18S, and 55S; base composition of the two high molecular weight RNA components differs.

WASHINGTON STATE UNIVERSITY, 1849

Snow catch in coniferous crowns.

D. R. SATTERLUND

An analysis of the data collected during the winter of 1970-71 confirmed that growth in height of the surrounding forest modifies snow catch (greater) and loss (less) from the experimental trees so that their interception characteristics are no longer representative of forest trees in the crown canopy. The primary modification has resulted from a change in the microclimate due to greater shading and less air movement. The data still fail to demonstrate a discernible relationship between snow catch (and loss) and crown morphology. Hence, any relationship appears to be masked by the dominance of weather factors and the interaction of surrounding trees with the experimental trees.

UNIVERSITY OF WASHINGTON, 1

Effect of nitrogen on growth of Douglas-fir.

S. P. GESSEL and T. N. STOATE

The project now has 490 major permanent plots, most of which were measured following the 1968 growing season or later; many were measured in 1971. In addition, a number of smaller plots have been established and the effects of minor elements tested on them. Project results include a possible explanation of poor response to nitrogen in certain areas, growth curves for individual trees over a 12-year period, the effect of nitrogen on tree mortality, and a verification of volume calculations for fertilized trees. An additional study has been completed which shows that the effect of nitrogen on trees in 12 California plots is similar to that found in western Washington.

UNIVERSITY OF WASHINGTON, 4

Influence of environment on quality of wood of Douglas-fir.

J. S. BETHEL

Relationships between wood quality and environmental factors were investigated in a broad program emphasizing mathematical and biochemical approaches. Specific goals included production of a mathematical model for xylem formation and development of media for Douglas-fir tissue culture. *Xylem Production Model*: The amount of cell wall material per unit area within annual growth increments of coniferous woods increases from springwood to summerwood. A model has been devised to describe the pattern of ring development. The model correlated well with densitometer traces of grand fir (*Abies grandis* (Dougl.) Lindl.). This species was chosen for initial tests because of its somewhat simpler anatomical structure. *Tissue Culture*: Tissue culture techniques provide a tool for determining the nutritional requirements of isolated cell groups. These requirements are generally more complex than those of the tree itself, since the excised tissue lacks a portion of the trees' synthesizing ability. Culture media therefore generally include many complex organic substances in addition to the usual inorganic nutrients. *Minimal Medium*: The nutritional requirements of a tissue are established by finding the least complex medium that will allow continued growth. A formulation minimal in regard to organic constituents other than glucose was developed for cultures of lateral meristematic tissue of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). A medium designed for tobacco tissue cultures by Murashige and Skoog in 1962 (*Physiologia plantarum* 15:473-497.) was used as a starting point. Twenty-one new media were developed and tested. Only two organics, *myo*-inositol and α -maphthalene acetic acid, were found to be essential for growth of this tissue strain. Omission of either or both of the substances results in death of the tissue within 3 to 5 months.

The simplicity of this medium should prove useful in future studies of Douglas-fir growth processes by reducing interaction of the medium with experimental variables. *Differentiation*: Excised plant tissues are generally undifferentiated since they are no longer regulated by the biochemical control signals of the intact organism. The usual appearance of cultured Douglas-fir tissue is shown in figure 9.

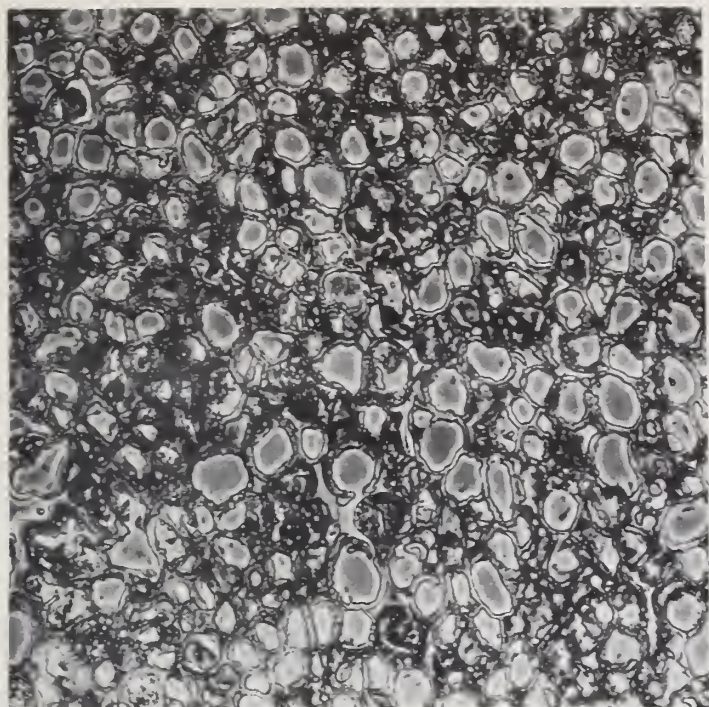


Figure 9. Undifferentiated Douglas-fir tissue.



Figure 10. Growing tip of root-like structure in partially differentiated Douglas-fir callus.

Numerous attempts were made to simulate the tree's control system and induce differentiation by modification of the culture medium. Several instances of differentiation were observed, including the root-like structure shown in figure 10. Induction of differentiated tissue under these conditions should give an insight into growth processes and control mechanisms of living trees.

ADDITIONAL PROJECTS

ALABAMA—AUBURN UNIVERSITY, 904

Physiological factors affecting resistance of woody plants to certain phytocides. M. C. CARTER

ALABAMA—AUBURN UNIVERSITY, 913

Nitrogen fertilization of loblolly pine (Pinus taeda L.).

M. C. CARTER, E. S. LYLE, JR., and J. GOODING

UNIVERSITY OF ALASKA, 270—0541

Forest succession and soil moisture retention on upland sites in the Fairbanks area. B. J. NEILAND

UNIVERSITY OF ARKANSAS, 749

Establishment of forest trees in Arkansas. H. A. HOLT

CALIFORNIA—HUMBOLDT STATE COLLEGE, 26

Calorific values of sequoia sempervirens tissue samples. R. A. HURSEY and D. L. ADAMS

UNIVERSITY OF CALIFORNIA, 2179

Ecological potential of coast redwood. E. C. STONE

UNIVERSITY OF FLORIDA, 01534

Fertilization and nutrition of southern pine.

W. L. PRITCHETT

UNIVERSITY OF GEORGIA, 14

Physiology and biosynthesis of oleoresin in naval stores pines. C. L. BROWN

UNIVERSITY OF IDAHO, 2

Elongation and activity of roots of coniferous seedlings as determined by radioactive tracers.

H. LOEWENSTEIN

UNIVERSITY OF IDAHO, 16

Forest fertilization: its influence on stands of Douglas-fir and grand fir in Idaho.

H. LOEWENSTEIN and F. H. PITKIN

- UNIVERSITY OF ILLINOIS, 360
Soil moisture stress and land growth and wood of loblolly pine. A. R. GILMORE
- SOUTHERN ILLINOIS UNIVERSITY, 71-R-003
Effects of sulfur dioxide on seedlings of Pinus strobus L. and liriiodenron tulipifera L. C. A. BUDELSKY
- INDIANA-PURDUE UNIVERSITY, 1476
Establishment and culture of black walnut, tulip poplar, and cottonwood. W. R. BYRNES
- INDIANA-PURDUE UNIVERSITY, 1477
Ordination for forest ecosystems. C. MERRITT
- KANSAS STATE UNIVERSITY, 770
Hardwood species and cultural practices needed for rapid fiber production. W. A. GEYER
- UNIVERSITY OF KENTUCKY, 604
Physiology and genetics of hardwoods. S. B. CARPENTER
- LOUISIANA STATE UNIVERSITY, 1538
Effects of silvicultural treatments on wood properties of even-aged loblolly pine plantations. E. T. CHOONG and P. J. FOGG
- UNIVERSITY OF MAINE, 5002
Factors affecting growth of commercial forest tree species in Maine. C. E. SCHOMAKER and R. A. STRUCHTEMEYER
- UNIVERSITY OF MAINE, 5006
Woody fiber production and utilization of complete trees and shrubs. H. E. YOUNG
- UNIVERSITY OF MASSACHUSETTS, 10
Role of mechanical stress in cambial activity of trees. B. F. WILSON and R. R. ARCHER
- MICHIGAN STATE UNIVERSITY, 979
Nutrition of tree seedlings and optimizing site conditions for seedling establishment and tree growth. G. SCHNEIDER
- UNIVERSITY OF MICHIGAN, 8
Biosystematics of birch complex. B. V. BARNES
- MISSISSIPPI STATE UNIVERSITY, 3-205-1122
Multinodal growth shoot systems in loblolly pine plantations. W. W. ELAM
- MISSISSIPPI STATE UNIVERSITY, 3-205-1128
Nutrient cycle in loblolly pine plantations. G. L. SWITZER and L. E. NELSON
- UNIVERSITY OF MISSOURI, 160
Protein synthesis mechanisms and morphology of tree seedlings during winter. G. N. BROWN
- UNIVERSITY OF MISSOURI, 162
Certain aspects of hardwood forest ecology. G. S. COX and W. L. DECKER
- UNIVERSITY OF NEVADA, 674
Survival of grass and tree species at high elevation in the Sierra Nevada. E. L. MILLER
- NEW JERSEY-RUTGERS STATE UNIVERSITY, 245
Physiological and biochemical study of phase change in plants. C. E. HESS
- NEW MEXICO STATE UNIVERSITY, 5
Soil-site requirements for ponderosa pine. A. G. WOLLUM
- NEW MEXICO STATE UNIVERSITY, 10
Effects of nitrogen fertilization on growth and deer use of browse species in pinon-juniper woodland. V. W. HOWARD, JR.
- NEW YORK-STATE COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 111-2-3
Biochemistry of tree seed dormancy and early germination. E. SONDEHEIMER
- NEW YORK-STATE COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 111-2-6
Tree growth studies. H. B. TEPPER, H. E. WILCOX, and F. A. VALENTINE
- OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, 5
Juvenile growth of northern red oak. A. R. VOGT
- OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, 6
Physiology of the formation of wood in oak and pine. F. W. WHITMORE
- OKLAHOMA STATE UNIVERSITY, 1332

Metabolism and movement of herbicides in woody plants.
E. BASLER

OREGON STATE UNIVERSITY, 794

Transpiration of Douglas-fir seedlings.

W. K. FERRELL

OREGON STATE UNIVERSITY, F880

An environmental and physiological response model of Douglas-fir growth.

R. H. WARING

OREGON STATE UNIVERSITY, F881

Floral initiation on juvenile Douglas-fir.

D. P. LAVENDER and K. K. CHING

SOUTH CAROLINA-CLEMSON UNIVERSITY, 2
Effects of irrigation on selected wood properties of upland hardwoods.

T. E. WOOTEN

SOUTH CAROLINA-CLEMSON UNIVERSITY, 853

Control of gas exchange in pine needles.

R. M. ALLEN

TEXAS A&M UNIVERSITY, 1649

Field investigation of water stress and growth in loblolly pine.

D. M. MOEHRING

TEXAS-STEPHEN F. AUSTIN STATE UNIVERSITY, 4

Morphological and anatomical peculiarities of foliage in loblolly pine from Texas "Lost Pines" area.

M. V. BILAN

UNIVERSITY OF VERMONT, 11

Physiological mechanisms responsible for sap flow in sugar maples.

J. W. MARVIN

UNIVERSITY OF VERMONT, 12

Role of cell transitions in the physiology of some northern hardwoods.

F. M. LAING and J. W. MARVIN

UNIVERSITY OF WASHINGTON, 6

Ecology and physiology of Douglas-fir and true firs.

D. R. M. SCOTT

UNIVERSITY OF WISCONSIN, 1350

Metabolic antitranspirants on trees.

T. T. KOZLOWSKI

UNIVERSITY OF WYOMING, 880

Biotic communities of forest and grazing lands.

H. G. FISSER and L. I. PAINTER

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GENETICS AND BREEDING OF FOREST TREES

Research Problem Area 301

Forest practice today is based largely on wild forest trees. Unlike crop plants, trees have not undergone centuries of controlled selection and breeding to make them more useful to man. There is strong evidence that through application of genetic principles, we can produce tree varieties that grow faster, resist most major destructive pests, have specified wood properties, or yield more sap or gum. It should be feasible to develop straighter form, fewer limbs, and resistance to climatic extremes. Quality and yield of timber-related crops, such as naval stores, ample sap, and Christmas trees, can be improved through application of research findings.

AUBURN UNIVERSITY, 912

Genetics, breeding, and evaluation of certain forest trees in Alabama.
J. F. GOGGANS

Improved varieties of longleaf and loblolly pine for use in the piedmont and mountain regions of Alabama, and of longleaf, loblolly, and slash pine for use in the coastal plain of Alabama are being bred by selection methods. A total of 266 plus trees have been selected for use as parents of these varieties. These selected parents have been established in seed orchards having a total area of 125 acres. Expansion of these orchards is continuing. The oldest portions of the orchards are now bearing seeds.

Controlled crossing for the development of hybrid pines for use on extremely dry, sandy sites in the coastal plain has started, and various combinations of southern pines are planned. Most of the individual parents for the hybrids will be chosen from the plus trees used in the seed orchards of the selection varieties being developed.

Because of continued losses of excellent selected parent trees in the forest, a clone bank for safekeeping these trees has been established. It currently contains 4-6 ramets of 225 plus trees of loblolly, slash, longleaf, and shortleaf pines.

Comparison of grafting and budding trials with sycamore and sweetgum indicates that budding is an easier and faster method of vegetative propagation for these species. June was the best month to bud sweetgum, while August was the best month to bud sycamore.

UNIVERSITY OF FLORIDA, 1293

Stock-scion relationships of southern pine.

W. H. SMITH

Grafting techniques have been used for centuries and continue to be an important propagation tool. In tree improvement, grafting may be used for concentrating breeding stock, stimulating flowering, increasing seed yield and viability, and growing exotics on native hardy root stocks. Several different experiments were conducted to test such factors as growth regulators, immuno-suppressants, nutrition, irradiation, and environment on grafted pine. When the stocks were fertilized with nitrogen prior to grafting, grafting success was reduced. Perhaps this is related to differential growth rates of stock over scion. Other chemicals had no effect on grafting success. Radiation treatment of scions reduced the growth of these scions after grafting, but did not affect the success of union formation. In tests comparing all treatments on easy- and difficult-to-graft combinations, grafting success was more sensitive to prevention of desiccation or maintenance of humidity than other treatments. Either shade, an intermittent mist system, or closed polyethylene bags (permeable to gases but not to moisture) were effective in maintaining high humidities during critical stages of union formation. Thus, these related experiments emphasize the importance of maintaining humid environments around grafts to prevent desiccation. By maintaining humid aerial environments with mist or by closed polyethylene bags, successful grafting of known difficult grafters was achieved.

UNIVERSITY OF FLORIDA, 1344

Improvement of sand pine for reforestation of the Florida sandhills.

R. K. STRICKLAND and R. E. GODDARD

Sand pine is a scrub species which survives and grows on the deep sands of central and west Florida better than other coniferous species, but the trees are usually of very poor form. Improvement of this species for reforestation of deep sand sites is being sought by simultaneous application of two procedures: (1) a clonal seed orchard, and (2) reselection among open-pollinated progenies of selections for a seedling orchard. Both seedling and the establishment of a clonal orchard were completed using scions or seed from approximately 70 selections in the Ocala race.

Supplementary tests established in four locations indicate significantly superior outplanting survival of the Choctawhatchee race over the Ocala race. For this reason, additional selections were made in the Choctawhatchee race, and cones and scions were collected for establishment of clonal and seedling orchards of this race.

Work toward improvement of the Choctawhatchee race will proceed in the same manner as the approach used with the Ocala race. The probable cause of poor outplanting survival of the Ocala race is its apparent lack of a dormant period (unlike the Choctawhatchee race, which becomes dormant). Because of geographic isolation and variation in flowering dates, there is probably little gene flow between the two races. Hybridization may, therefore, offer another approach to improvement of this species, and some crosses are currently being made.

SOUTHERN ILLINOIS UNIVERSITY, 69-R-011
Genotypic variation in black walnut-growth patterns for 20 geographic sources.

P. L. ROTH, J. TOLIVER, and C. F. BEY

Research showed that southern sources of 3-year old black walnut (*Juglans nigra* L.) grew faster and longer than northern sources in an Illinois plantation near McClure, Ill. The bimodal nature of the average weekly height growth was best explained by the pattern of rainfall and soil moisture. Growth was less closely related with air and soil temperature. Southern sources flushed before northern

sources and dropped their leaves later than northern sources. Variation among sources was clinal in a north to south direction. The data indicate that genetic gains might be possible by planting southern seed in more a northerly location.

Trees from northern sources dropped leaves significantly earlier than those from southern sources ($r^2 = 0.77$). The period between growth cessation and leaf fall was 9 to 13 weeks for all sources. There was no apparent problem. Although there was no problem of winter hardiness at 3 years of age, the movement of seed north should be limited to 150 miles. Sources from further south may flush before the chance of spring frost is past.

MICHIGAN STATE UNIVERSITY, 936

Genetic variation in physiological responses of trees to environment.
J. W. HANOVER

The physical properties and distribution of foliar surface waxes were examined in different varieties of blue spruce and in eight other conifers and one hardwood, including white spruce, Engelmann-spruce, white fir, Douglas-fir, Austrian pine, Scotch pine, eastern white pine, western white pine, and silver maple. Foliage was affixed to carbon discs, coated with a gold-palladium alloy, and examined directly under vacuum with a scanning electron microscope minutes after severance from the tree.

Two basic physical types of wax were found on the leaf surfaces: a structural type which is mainly responsible for leaf glaucousness, and an amorphous type. There was also considerable quantitative variation in waxes between species, within species, within trees, and within individual needles.

The most striking result from the study was the close association found between surface waxes of both types and the stomates. This relationship is quite evident in figures 11 and 12. Conifer species such as Austrian pine, which have little wax over most of their surface, still have wax occlusions in the epistomatal chambers. The silver maple leaf has a glaucous undersurface only, which results from the presence of waxes similar in structure to those of the conifers (fig. 13). The intimate relationship between the waxes and stomates is also apparent in silver maple.

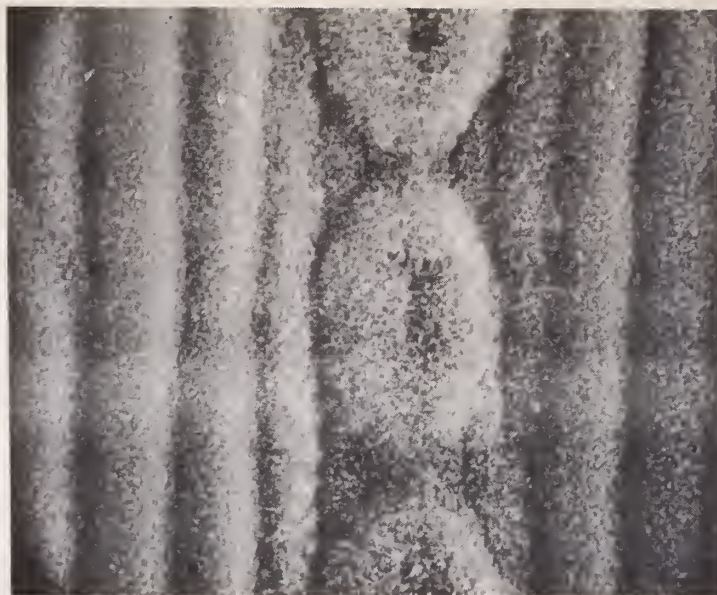


Figure 11. Surface wax deposits on an eastern white pine needle showing a portion of one stomatal row. X-1000.

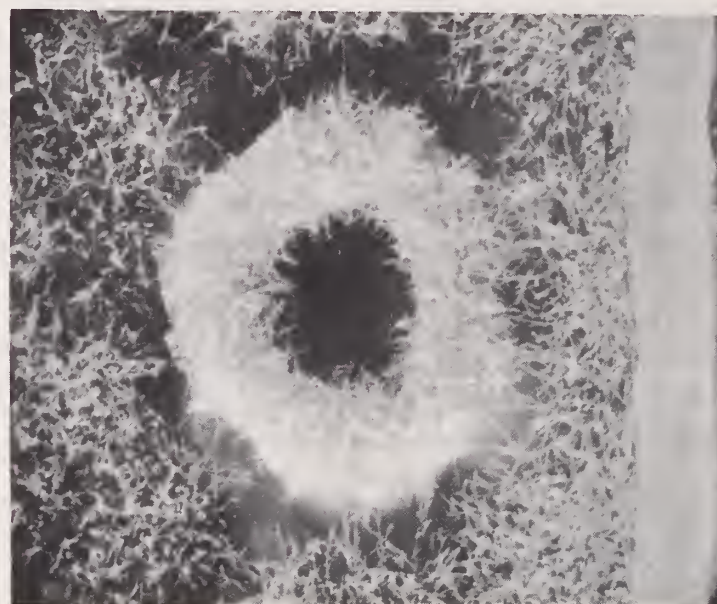


Figure 12. Surface wax deposits on a Scotch pine needle showing one stoma. X-2000.

It is suggested that the surface waxes may have a more prominent role than heretofore recognized in the regulation of rate of moisture and other gaseous exchange with the atmosphere, protection against mechanical and pest damage, and protection against ultraviolet radiation and air pollution.

UNIVERSITY OF MISSOURI, 164

Genetic investigations in forestation. R. B. POLK

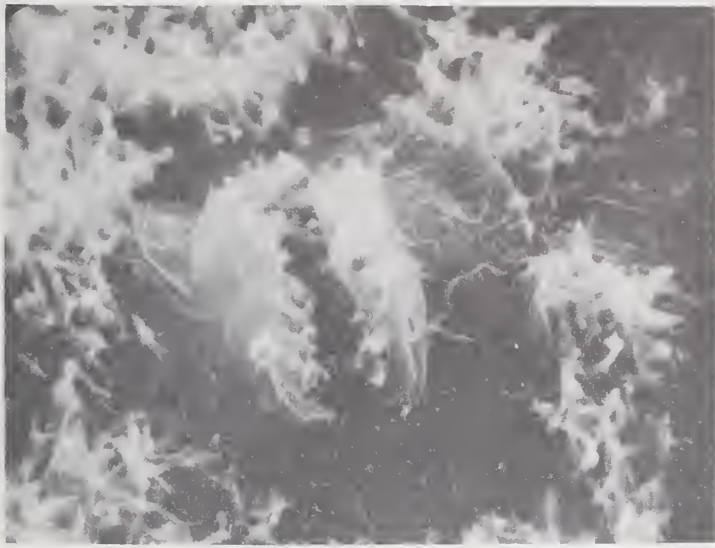


Figure 13. Surface wax deposits in and around one stomate on a silver maple leaf. X-5000.

Sixteen full-sibling (two parents in common) and 21 half-sibling (one parent in common) progenies of *Pinus banksiana* are in the nursery. The two-parent progenies represent assortative matings of selected parents, and the one-parent family lines are from superior mother trees randomly pollinated by males in an upgraded population. The objective is to obtain from this very variable pine species a synthetic variety for Christmas tree production and various amenity uses.

On an area being developed into a *Pinus sylvestris* breeding orchard with eventual 24 x 24-foot spacing, a 6 x 6-foot filler planting was made, using 15 commercial varieties of the species in 10-tree plots with six replications. In addition to testing these varieties, this planting will provide some protection to the young orchard trees from sapsuckers, deer, and theft.

Research designed to investigate the role of moisture in *Pinus* seed production continued, as follows: (1) Plots of *Pinus sylvestris*, *P. banksiana*, *P. rigida*, and *P. virginiana* were established on five soils representing different levels and depths of subirrigation and drainage; and (2) a subirrigation and drainage system was installed in a 15-plot sequence designed to achieve gradient changes in irrigation and drainage.

In other work, provenance plantings of *Pinus sylvestris*, *P. banksiana*, *P. ponderosa*, and *Pseudotsuga menziesii* were maintained. The provenance plantings of *Pinus Ponderosa* (two 3,248-tree plantations) and *Pinus banksiana* (one 960-tree plantation) were measured. Twenty young *Pinus sylvestris* graft clones on two kinds of rootstock were tended.

UNIVERSITY OF MONTANA, 210-0904

Hybridization of western and subalpine larch.

G. M. BLAKE

Three aspects of the project were investigated which resulted in the following:

- (1) A comprehensive study of the ecology of subalpine larch was completed. The results of this undertaking have greatly increased an understanding of the fundamental differences between western and subalpine larch.
- (2) A range map of the two species was updated. New areas of range overlap, where possible introgression may be taking place, were located. Further ground reconnaissance of these areas is planned.
- (3) The relationship of stocking level to total stand productivity in second-growth western larch is being investigated. Ten-year results are presently being analyzed.

NEW YORK-STATE COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 301-1-2

Genetic improvement in hardwoods.

W. T. GLADSTONE

A study of intraclonal variability in chemical and pulping characteristics of hybrid poplar wood has been concluded. Assessment of established provenance and progeny tests in sugar maple, black cherry, yellow birch, and alder continues, though funding of the project terminated July 1, 1971. Seeds were collected from trees of two species, *Ailanthus altissima* and *Acer rubrum*, for provenance studies in cooperation with V.P.I. and the Agricultural Research Service, USDA, shade tree lab, respectively.

R. C. KELLISON

A study of the geographic variation of yellow-poplar in North Carolina was initiated in 1962. Four trees from each of nine stands in each of three physiographic provinces (total of 108 trees) were studied for their wood, leaf, and reproductive properties and for tree form. The pattern of variation of most characteristics studied was clinal, increasing in magnitude from the coast to the mountains. One population, consisting of three stands and located on the organic, high acid soils of southeastern North Carolina, was so different in every characteristic studied that it was suspected of being a distinct ecotype. Phase II of the study consisted of progeny testing the parental trees, first in the nursery and then in plantations. Statistical differences ($P=0.01$) were observed in the nursery for seedling height and for the leaf characteristics of top-sinus depth, side-sinus depth, and shape. Ranges among populations in heritability were: height, 0.24 to 1.18; top sinus depth, 0.18 to 0.61; side sinus depth, 0.01 to 0.70; and shape, 0.19 to 0.58. Survival and growth data on the 2- and 4-year old trees in the plantation showed performance within a plantation to be strongly influenced by source. The conclusions were that (1) North Carolina be divided into four zones for the collection of yellow-poplar seed; (2) a distinct ecotype of yellow-poplar exists in the lower coastal plain; and (3) the variation among parent trees is sufficiently great to warrant a selection breeding scheme for the genetic improvement of yellow-poplar.

NORTH CAROLINA STATE UNIVERSITY, 4016
*Taxonomic relationship of *pinus rigida* and *pinus serotina*.*
L. C. SAYLOR

A number of populations of *pinus rigida* and *pinus serotina* were sampled from the natural ranges of the two taxa and from the transition zone in the Delmarva Peninsula and southeastern New Jersey (fig. 14). Bud and seed characteristics, along with cone length, were found to be quite similar in the two taxa. Other features, such as needle length, peduncle length, cone diameter, and serotiny differed. All these characters varied clinally within each taxon, and these clinal patterns converged toward the

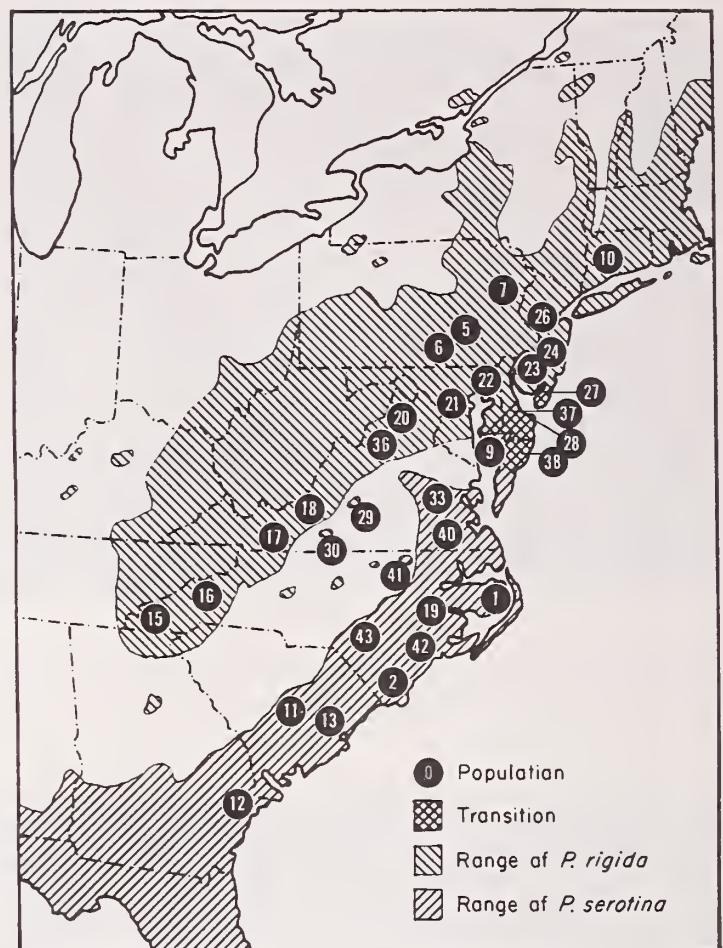


Figure 14. Locations of populations of pines sampled from the natural ranges of two taxa and the transition zone in the Delmarva Peninsula and southeastern New Jersey.

transition zone. The natural populations of this zone possessed characteristics of a single taxon that were morphologically intermediate between nearby populations of a single geographically variable complex. Evidence was detected of a local steepening of the morphological gradation through the transition zone. This was interpreted as data supporting a system of secondary intergradation rather than of primary radiation.

Hybridization between *P. taeda* and the *P. rigida-serotina* complex was common, and genetic exchange occurred in both directions. Hybridization between *P. echinata* and the *P. rigida-serotina* complex was more restricted, as was hybridization between *P. taeda* and *P. echinata*. All three of these entities (*P. taeda*, *P. echinata*, and the *P. rigida-serotina* complex) were found to maintain their separate identities in mixed populations, despite hybridization. The distinctiveness of *P. taeda*, *P. echinata*, and the *P. rigida-serotina* complex was in

marked contrast with the lack of distinctiveness within the complex itself.

The results of the taxonomic and hybridization studies indicate that Clausen's classification of 1939 was most correct—the two taxa should be considered subspecies, that is, *P. rigida* ssp. *rigida* and *P. rigida* ssp. *serotina*.

OREGON STATE UNIVERSITY, 759

Genetic variation of Douglas-fir ecotypes in photo-response. MOLLER H. IRGENS

Half-sib families from trees in Montana, Idaho, Colorado, New Mexico, and Arizona were grown in controlled environment chambers for about 6 months at age 3 years. Laboratory measurements on photosynthetic rates of 20 seedlings from each family showed that those native to Idaho-Montana had very high rates of assimilation (up to 18 mg CO₂/g dry weight/hour), in contrast with a considerably lower rate in those from New Mexico-Arizona. The high rates in the northern families probably reflect the much shorter season favorable for growth in that area, compared with further South. The annual distribution of rainfall in the North is mainly in the winter months, while it is more evenly distributed in the South. This adaptation to the local climate is also evident in the growth rates of various types when grown out-of-doors at Corvallis. The Arizona and New Mexico types grow about two to three times more than the northern types. Laboratory measurements of photosynthetic rates are therefore not very well suited as a method of screening plants for fast growth. Such measurements must be made under field conditions and be based on the total annual net assimilation by periodic measurements throughout the year.

OREGON STATE UNIVERSITY, 760

Comparative development of Douglas-fir seed from high and low elevation trees. W. P. WHEELER

Sequence and pattern of embryonic development and cell division are equivalent at both high and low elevations, although fertilization occurs later at the higher elevation. Temperature positively correlated with embryo development, particularly during period of accelerated growth. Apical initial zones of root and shoot, once delineated, show little or no

activity. Mitotic inception during reactivation occurs peripheral to the apical initial cells which divide last. Root initials consist of a single layer 5-7 cells in width. Decrease in root width is negatively correlated with seedling age due to decrease in root meristem. The root column is discrete and a quiescent center in the root initial and mothercell zones is confirmed. Shoot apical initials incorporate H³-thymidine indicating active DNA synthesis. Diurnal periodicity of cell division is not evident and the mitotic index of 6.4 percent and cycle of 33 hours are representative for root meristems upon reactivation. A shorter mitotic cycle during later stages in ontogeny is indicated. Mitoses unaccompanied by autoradiographic images are considered due to diploid embryonic cells in the G2 (4C) stage during exposure to H³-thymidine. Labeled nondividing cells during late ontogeny are attributed to endopolyploidy and/or DNA exchange.

OREGON STATE UNIVERSITY, 762

Flower induction on juvenile Douglas-fir.

D. P. LAVENDER and K. K. CHING

This experiment was designed to determine if modifications of the physical environment will induce precocious flowering in previously nonfertile Douglas-fir seedlings and increase flower production on physiologically fertile scionwood grafted on juvenile plants. A plantation of 3-0 Douglas-fir was established in 1965 and trees of various groups were treated with various modifications of the environment through the use of fabricated plastic and wooden enclosures equipped with evaporative coolers and appropriate heating devices.

Sporadic flower production, both female and male, occurred on seedlings and grafts throughout different treatments. No clear trend or correlation could be found between treatments and flower production. However, the majority of both male and female flowers were produced on seedlings 7 years or older. This seems to confirm some of the current hypotheses that flowering in tree species is correlated with the age and size of the plant.

SOUTH CAROLINA-CLEMSON UNIVERSITY, 704

Genetics of forest trees.

R. E. SCHOENIKE

Two small testing plantings of deodar cedar were established on the Clemson forest in March 1967—on an abandoned old field with broomsedge (*Andropogon* spp.) cover and on a cutover hardwood forest site with a steep easterly-facing slope. A 10-tree row plot was used as the basic design.

In December 1970, survival and growth tabulations were made on all plots. On the old field site consisting of five replications of six different seedling lots, survival averaged 50 percent and mean height was 2.3 feet. On the hardwood forest site which consisted of two to five replications of 13 different seedling lots, survival averaged 73 percent and mean height was 3.1 feet. For those seedling lots represented on both sites, both survival (50 percent greater) and total height (40 percent greater) were better on the forested site. Deodar cedar exhibits a preference for forested sites with cool, well-drained slopes, and nearly full sunlight. Its overall growth pattern as a forest species approximates that of Eastern Hemlock.

Sawtooth oak is a Japanese species that is easily established, grows rapidly, and produces large quantities of acorns at an early age. Sawtooth oak seedlings outplanted on an old field site had first year survival of 86 percent, which subsequently has declined to 51 percent. Considerable mortality from small mammals, probably mice, was noted in the winter of 1968-69. After five growing seasons, the mean height was 4.7 feet, ranging from less than 2 to over 11 feet. The trees tended to be bushy and have somewhat crooked stems. No fruiting has been observed thus far, although male catkins were seen on some trees in May 1971. Sawtooth oak shows promise of developing into a tree that will be useful for wildlife purposes in open old field sites in the South Carolina Piedmont.

Deodar cedar seedlings were distributed to eight Christmas tree growers in South Carolina in 1969. One grower reported sales of up to \$10 per tree in the Christmas 1971 season.

Sawtooth oak is now being grown in several Southern and Central States as far north as Ohio. It also has shown promise as an ornamental, having a bushy crown, and dark green, chestnut-like leaves that turn golden yellow in fall.

TEXAS—STEPHEN F. AUSTIN STATE UNIVERSITY, 2

Initial root growth and development in loblolly pines from "Lost Pines" and east Texas areas.

M. V. BILAN

Loblolly pine (*Pinus taeda* L.) in the "Lost Pines" area of Texas seems more drought resistant than those of east Texas and possibly more suitable for planting on dry sites. This study compounds the growth and development of seedlings from these two seed sources. Multiple sets of two experimental pines (one of each seed source) are grown from seed in soil-filled clear plastic tubes kept at a 45°-angle to facilitate root growth along the transparent wall of the tube (fig. 15).

Periodic tracings on overlaid acetate paper make it possible to study root growth without disturbing the plants. Measurements of these tracings are tabulated for analysis and presentation. The tracing



Figure 15. Root growth is studied by periodic tracings of the new roots in loblolly pine seedlings growing in acrylic resin tubes.

information is supplemented at less frequent intervals by data obtained from measurements of washed-out sets of root systems.

The highest average elongation of main root—approximately 5.5 centimeters for both seed sources—occurred during the fourth week after germination. After 20 weeks of growth, the average length of main root per seedling was 70 centimeters for east Texas and 74 centimeters for Lost Pines. Total average length of all lateral roots per seedling was 354 centimeters for both seed sources.

Average length of main root in 1-year-old seedlings was 92 centimeters for east Texas seed source and 100 centimeters for Lost Pines. Total average length of all lateral roots per seedling was about 1,000 centimeters for both seed sources, but the number of the first order lateral roots was about 13 percent greater in seedlings from Lost Pines. Height growth and dry matter production per plant were about the same for both seed sources.

Similar plantings in tubes are being used to study the effects of soil moisture stress on root growth and survival of seedlings from the two seed sources.

TEXAS—STEPHEN F. AUSTIN STATE UNIVERSITY, 3

Estimation of morphological variance and preliminary evaluation of hybridity among east Texas pines.
R. R. HICKS, JR.

Research has begun on estimating morphological variance and preliminary evaluation of hybridity among east Texas pines. Results of a pollen phenology study indicate that a sufficient overlap in pollen release exists between loblolly and shortleaf pines in east Texas to allow for natural hybridization. Of the 12 morphological characteristics examined, needle length, number of needles per fascicle, length of fascicle sheath, width of terminal bud, cone length, and seed weight were found to be best characters to use for identifying loblolly pine, shortleaf pine, and loblolly-shortleaf hybrids.

UNIVERSITY OF WISCONSIN, 1785

Breeding for disease resistance in ulmus.

D. T. LESTER and E. B. SMALLEY

The potential for development of elms genetically resistant to the Dutch elm disease is being explored in various elm species. American elms that survived several artificial inoculations with disease spores have been crossed and propagated by cuttings to test maintenance of resistance following propagation. In both seedlings and cuttings tested at age 2 years, there has been little evidence of resistance. New studies will investigate the failure of parental resistance mechanisms to operate in cuttings. At present, development of genetically resistant American elms is not promising.

Prospects for development of ornamental, disease-resistant elms through combining Asian species are good. Siberian elm is highly resistant to Dutch elm disease, but lacks satisfactory ornamental qualities. Japanese elm is only moderately resistant, but exhibits attractive leaf and branch characteristics. Crosses between these species have resulted in seedlings with high resistance and apparent ornamental potential. Introduction of genes from slippery elm enhanced ornamental traits, but raised disease susceptibility in proportion to the amount



Figure 16. Japanese elm now 15 years old survived three Dutch elm disease inoculations.

of slippery elm germ plasm represented. For seed propagation, crosses of Siberian and Japanese elms are highly promising. For propagation by cuttings, resistant individuals in species combinations including slippery elm may be selected and produced for commercial use.

Patterns of seasonal response to fungal inoculation were determined in cuttings from 15 parents of highly diverse genetic background, including genes from Asian, American, and European species. The parents had been selected for ornamental traits and symptomless response to fungal inoculation. Two clones showed high resistance throughout the growing season (fig. 16). These clones are to be released for commercial use.

ADDITIONAL PROJECTS

UNIVERSITY OF ARIZONA, 2016-4168-025

Tree species for Christmas trees in the Southwest.

R. F. WAGLE

CALIFORNIA-HUMBOLDT STATE COLLEGE, 11

A provenance study of coast redwood (Sequoia sempervirens). J. H. HANSEN and J. A. HELMS

COLORADO STATE UNIVERSITY, 319

Crossability and compatibility patterns in spruce.

G. H. FECHNER

UNIVERSITY OF IDAHO, 3

Heritability and population structure of ponderosa pine. C. W. WANG

SOUTHERN ILLINOIS UNIVERSITY, 69-B-001

Structural studies of early and delayed graft incompatibility in Juglans. M. KAEISER

SOUTHERN ILLINOIS UNIVERSITY, 70-R-21

Effects of soil temperature on growth of black walnut seedlings under greenhouse conditions.

J. S. FRALISH

SOUTHERN ILLINOIS UNIVERSITY, 70-R-25

Genetic variability of apical dominance in black walnut (Juglans nigra L.). P. L. ROTH and C. F. BEY

SOUTHERN ILLINOIS UNIVERSITY, 70-R-26

Selection of black walnut (Juglans nigra L.) for late flushing, cold hardiness, and rapid growth.

P. L. ROTH, C. F. BEY, and R. H. KAMMLER

IOWA STATE UNIVERSITY, 1872

A physiological analysis of wood fiber yield.

J. C. GORDON and D. I. DICKMANN

KANSAS STATE UNIVERSITY, 771

Forest tree improvement for Kansas through selection and breeding. R. W. FUNSCH

UNIVERSITY OF MAINE, 5011

Soil-tree relationships and their effect on tree growth in Maine. R. A. STRUCHTEMEYER

UNIVERSITY OF MARYLAND, L-100

Vegetative propagation of pines by needle fascicles. J. B. SHANKS

MICHIGAN STATE UNIVERSITY, 1061

Forest tree improvement through selection and breeding. J. W. WRIGHT

UNIVERSITY OF MINNESOTA, 19-078

Hybridization in populus. C. A. MOHN

NORTH CAROLINA STATE UNIVERSITY, 4002

Wood property variation in sycamore.

R. C. KELLISON

NORTH CAROLINA STATE UNIVERSITY, 4010

Physiological bases of genetic superiority.

T. C. PERRY

NORTH CAROLINA STATE UNIVERSITY, 4023

Variation of white oak in the southern Appalachians. J. W. HARDIN and M. J. BARANSKI

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, 2

White pine seed development in relation to sterility barriers, inbreeding depression, and hybrid vigor.

H. B. KRIEBEL

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, 7

Physiological genetics of forest trees.

D. B. HOUSTON and B. A. THIELGES

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, 9

Selection and breeding of forest trees.

B. A. THIELGES and D. B. HOUSTON

OKLAHOMA STATE UNIVERSITY, 1241
Clinal variation in shortleaf pine.
R. W. STONECYPHER

OKLAHOMA STATE UNIVERSITY, 1304
Improved loblolly and shortleaf pine.
R. W. STONECYPHER

OKLAHOMA STATE UNIVERSITY, 1348
Evaluation of shortleaf x slash pine hybrids.
R. W. STONECYPHER

OKLAHOMA STATE UNIVERSITY, 1349
Cottonwood improvement. R. W. STONECYPHER

SOUTH CAROLINA-CLEMSON UNIVERSITY,
705
Inbreeding Virginia pine. R. E. SCHOENIKE

SOUTH CAROLINA-CLEMSON UNIVERSITY,
717
*Variation and tree improvement studies in the genus
quercus.* R. E. SCHOENIKE

SOUTH CAROLINA-CLEMSON UNIVERSITY,
881
Variation and inheritance of longleaf pine.
R. E. SCHOENIKE

UNIVERSITY OF TENNESSEE, 8
Christmas tree breeding. E. THOR

TEXAS A&M UNIVERSITY, 1826
In vitro cultivation of woody plant cells.
D. F. DURSO

TEXAS-STEPHEN F. AUSTIN STATE UNI-
VERSITY, 9
Testing river birch for silage cellulose production.
R. R. HICKS, JR.

TEXAS-STEPHEN F. AUSTIN STATE UNI-
VERSITY, 12
*Estimating the frequency of natural loblolly x
shortleaf pine hybrids in east Texas.*
R. R. HICKS, JR.

VIRGINIA POLYTECHNIC INSTITUTE, 636159
*Genetic evaluation of ailanthus altissima (Mill.)
swingle.* P. P. FERET

WASHINGTON STATE UNIVERSITY, 41
*Development of superior seeds for plantation
Christmas trees.*
R. W. DINGLE and P. C. CRANDALL

WASHINGTON STATE UNIVERSITY, 1771
*Genetics of multinodalness in lodgepole pine (Pinus
contorta Dougl.).* R. M. DINGLE

UNIVERSITY OF WASHINGTON, 16
Genetic studies of Pacific Northwest hardwoods.
R. F. STETTLER

WEST VIRGINIA UNIVERSITY, 1
Selection of valuable hardwoods. F. C. CECHE

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FISH AND OTHER MARINE LIFE, FUR-BEARING ANIMALS, AND OTHER WILDLIFE

Research Problem Area 904

Research on wildlife, fur-bearing animals, and fish and other marine life is needed to meet the ever-growing demands of hunters, trappers, and fishermen; to develop improved production of farm-reared fish and fur-bearing animals; and to

assure continuing supplies of marine life for food and other purposes.

To maintain and increase the supply of wildlife, fish, and other marine life, it is essential to know how to maintain and enhance their habitat and to determine the biological requirements and relationships of each species, including cover and food for normal growth.

Increased knowledge of fish biology is needed to put commercial production of fish in farm ponds and lakes on a paying basis.

UNIVERSITY OF CONNECTICUT, 340
Fetal sex ratio and productivity of white-tailed deer.
R. D. McDOWELL

Embryo counts from 8,564 gravid white-tailed does, recorded by game biologists from 20 Eastern States, were reduced to a universal format and then used to determine statistically the influence of maternal age, physiography, forest type, soil type, and land use on fecundity. Forest and soil were found to exert the greatest environmental influence on deer fertility. Accordingly, the entire Eastern region of the United States was divided into six major "fertility regions," based on a forest and soil classification (fig. 17). These fertility regions may be used by deer biologists in making both intrastate and interstate analyses.

Corpora lutea and/or corpora albicantia counts from 4,732 mature white-tailed does, recorded by game biologists from 15 Eastern States and Texas were stratified, as above. In addition, a new factor—population density—was used. Results of statistical analyses indicate that extremes in population density may override all other factors, including maternal age.

In a search for a more sensitive and more practical criterion of deer productivity, the yearling age class was examined more closely. There were two principal reasons for selecting this cohort. First, the sample was of sufficient size; second, results of the embryo count study had shown that yearlings were more responsive to environmental variations than were older dams. The yearling class was divided into first-bred and previously-bred does, based on absence or presence of corpora albicantia. In every category, environmental



Figure 17. Deer fertility regions of the northeastern United States.

or political, the latter significantly outproduced the former.

UNIVERSITY OF MASSACHUSETTS, 5

Food and shelter requirements of ruffed grouse in relation to energy regimes.

R. B. BRANDER, F. GREELEY, and J. S. LARSON

An effort has been made to quantify the energy regime of the ruffed grouse as it relates to the structure and composition of forest habitats. The application of radio-tracking techniques to grouse on a Massachusetts study area clearly showed that aspens (*Populus tremuloides* and *Populus grandidentata*) are integral food items in the winter diet of grouse, and that White Pine (*Pinus strobus*) and Hemlock (*Tsuga canadensis*) of certain densities are primary night roosts. The relationship of winter roosts of grouse to their food sources in our study area was investigated by examining fecal droppings for food remains and mapping snow and tree roosts in relation to food sources. Of 62 roosts, 47 percent were within 15 feet of species of trees bearing items which had been

identified in the droppings (that is, portions of buds). A regression of frequency of occurrence of roost distance from nearest source of plant parts found in the droppings was highly significant. Thirty-eight roosts were in aspen and mature white pine; nine were under scattered hemlock.

The caloric contents of fecal droppings and fresh food (male aspen and flowering buds) were determined to provide estimates of energy assimilation. To relate heat loss (through radiation from a hot body, that is, grouse) to forest structure, the shelter value of five selected forest canopies to grouse was measured with infra-red radiometers.

Temperature regulation was studied in 21 trials in February and March on 14 captive raised grouse in a metabolic chamber. Oxygen consumption for each trial was determined over a temperature range of $+20^{\circ}$ to -40°C . A regression describing the relationship of oxygen consumption to air temperature was derived for all grouse combined ($\text{Log}_{10} Y = 1.928 - 0.007X$). The standard metabolic rate, in ml. O_2 consumed/minute/gm. body weight, was not altered by differences in sex, month, or absorptive condition. There was a small change in the lower critical temperature from February to March.

A dynamic linear programming model was formulated to describe and analyze several alternative approaches to ruffed grouse habitat management.

MISSISSIPPI STATE UNIVERSITY, 3422

Effects of stand conversion on wildlife populations.

G. A. HURST

For the study of clearcutting and regeneration as they affect wildlife, three sections (640 acres)—each with a $\frac{1}{2}$ -mile buffer strip surrounding it—of uncut Interior Flatwoods forest were selected. An annual 80-acre clearcut is planned for each section for the next five summers. Baseline conditions in the uncut forest have been collected, that is, vegetation description (species composition and volume) and an intensive mast study. Vegetative conditions and the status of wildlife populations will be ascertained continuously as the three study areas are converted from mixed hardwoods and pine to pine plantations.

Another phase of the study deals with existing plantations in the area. The objective is to describe and evaluate various site preparations (figs. 18 and 19) and the resulting pine plantations as wildlife habitat. The site preparations will include mist blowing, injection, shearing, chipping, windrowing, burning, and bedding. Various combinations of these will be compared for their production of wildlife food. Vegetative analyses and indices of wildlife



Figure 18. Effects of various site preparations on wildlife habitat are being documented.



Figure 19. Windrowing is one site preparation technique being evaluated for production of wildlife food.

populations are being conducted and will continue for several years.

In conjunction with the evaluation of clearcuts for wildlife (game species) a nongame bird study is in progress. With the help of tape recorders, mist nets, visual observations, and human listening counts, information on the relative abundance of the various species and their use of different clearcuts will be obtained. It has already been shown that some clearcuts are excellent hawk habitat.

NEW MEXICO STATE UNIVERSITY, 2

Seasonal distribution of mule deer in relation to selected browse species and availability of water.

C. T. ENGELKING and V. W. HOWARD, JR.

Seasonal fluctuations in density and distribution of mule deer on the Fort Stanton Experimental Range continued throughout the past 12 months. The winter deer herd was estimated at 464 deer, while only 126 deer were estimated to be on the area during the summer months (June-August). This low summer population follows 2 successive years of below-average rainfall and 1 year of heavy use by livestock. These population estimates are approximately 0.50 and 0.35 times those for the same periods last year. Because of these large seasonal fluctuations, a deer trapping-marking program was initiated during the past year. Forty-eight individual deer have been marked, of which 38 are believed to be surviving. These animals will provide information on where the deer are going when they leave the area during the summer months.

The more open, better-watered portions of the area had 5.6 times as many deer as did those areas having lesser amounts of drinking water. Woody vegetation (browse) increased 2 percent in total ground cover on that part of the area receiving light use from livestock, while those areas receiving heavy use had a 7-percent decrease in ground cover of woody species, compared with 1965 data from the same transects. The areas having the decrease in woody vegetation are also supporting the higher deer populations.

The one-eighth acre bedding plots were read throughout the summer with very limited amounts of data collected. During the fall, 96 500-pace bedding transects were established on the area to determine

seasonal preference for bedding sites by deer. Hopefully, the transects will show preferences for habitat type, slope, and exposure on a seasonal basis.

NEW YORK—CORNELL UNIVERSITY, 907

Wildlife habitat changes resulting from the revegetation of abandoned farmland. J. W. CASLICK

Multiflora rose has been a difficult shrub to establish in New York, apparently because of insufficient moisture available to the small plants immediately after they are transplanted from the nursery into the field. When moisture is adequate, however, they become well-established within a year or two and their extensive root systems better enable them to compete successfully for moisture in dry years. Recommended site preparation is fall plowing prior to spring planting, followed by regular cultivation to eliminate competing plants for the first few years.

Experiments with new planting techniques show a very promising alternative method involving the use of black polyethylene plastic to provide a mulch. In an old field, strips of plastic mulch material about 2 feet wide should be laid down on each side of the row of new transplants. Generally, the transplants are spaced a foot apart in the row when a hedge is desired. Two such rows, 2 feet apart, will result in a much better hedge. In this case, three strips of plastic are needed; one strip to fill the area between the two rows. Special stakes can be used to anchor plastic to the ground, but a generous "sprinkling" of stones on the plastic serves this purpose well. Strips of plastic can be cut from wider rolls by using a fine-toothed saw to cut the intact roll into the desired widths.

This plastic mulch technique was tried on land that had been plowed and where the transplants were set directly into the old sod, without plowing. Even on a fairly severe hilltop site, all multiflora rose plantings have grown well where plastic mulch was used.

OKLAHOMA STATE UNIVERSITY, 1442

Compatibility of game and timber production on intensively managed lands. J. L. TEATE

Most commercial nurseries do not propagate native or wild species of plants. This situation seems especially strange in the Southeastern United States, where the flora is so esthetically pleasing to man and very important in the diet of wildlife native to this region.

After contacting every commercial nursery suggested by various sources, we finally were able to obtain most of the browse species to be included in this study. We are propagating the remainder of the species—those unobtainable from commercial sources—in our own greenhouse. The first field plantings will occur this spring.

Because of a 2,400-acre wildfire, many of the field plots previously selected had to be changed. This fire also caused a change in the study plan since it eliminated many plantations of specific age classes. As a result, we are unable to include slash pine as a variable in the study. Twelve new plots have been established, corner posts erected, and boundaries marked. All of these are in loblolly pine plantations representing four different age classes.

Measurements have been taken on those plants growing in the shade houses (figs. 20 and 21), representing four levels of light intensities, which were established last year. The data will be compared with information obtained in the field study plots, beginning with this year's growing season.

UNIVERSITY OF TENNESSEE, 6

Wood duck ecology on rivers and impoundments in east Tennessee. R. W. DIMMICK

The waterfowl population on the Holston River was censused during April and October 1971. The prebreeding census taken April 4 revealed that 659



Figure 20. Shade houses used to study the effect of differing amounts of light on growth and fruiting of important deer browse plants.



Figure 21. Plants in plastic pots set in shade houses in a mixture of sand, sawdust, and peat.

wood ducks were present on the study area. An additional 889 ducks of other species were present, giving a total of 1,548 waterfowl on the 31 miles of river. In October, 977 wood ducks were counted, along with 1,020 ducks of other species, for a total of 1,997 waterfowl. A work plan for the study of mercury in this river system is being prepared, and preliminary work accomplished.

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY, 636124

Effect of nutrient levels on reproductive function in white-tailed deer. **R. L. KIRKPATRICK**

A total of 320 deer rumen from six areas of the Southeast have been examined for both food items and their chemical composition over a 3-year period, and the data obtained placed on computer cards. Differences between areas, seasons, and years will be examined and any correlation between foods eaten and the approximate composition assessed. In analyzing these data, attention will be given to the alternative food sources that deer select when their primary foods are in short supply, and how the approximate composition of rumen contents is influenced by the alternative foods. Reproductive organs and pituitary glands of these deer are being examined to determine the relationship between their development and the composition of the rumen contents.

A second study is presently underway at the Savannah River Project of the Atomic Energy Commission in South Carolina, in which deer fawns are collected from two areas that differ markedly in

fawn reproduction. Physiologic characteristics of the deer are being examined in relation to food habits and the composition of the rumen contents.

ADDITIONAL PROJECTS

UNIVERSITY OF CONNECTICUT, 376

Habitat analyses of two northeastern cottontails.

R. D. McDOWELL

UNIVERSITY OF GEORGIA, 20

An evaluation of radioactive contaminants in wild animals of forest lands. **J. H. JENKINS**

SOUTHERN ILLINOIS UNIVERSITY, 07-067

*Dispersal of white-tailed deer (*Odocoileus virginianus*) from family units.* **W. D. KLIMSTRA**

SOUTHERN ILLINOIS UNIVERSITY, 01-070

Fawn mortality on crab orchard national wildlife refuge. **R. E. HAWKINS and W. D. KLIMSTRA**

LOUISIANA STATE UNIVERSITY, 1510

Population studies of woodcock in Louisiana.

F. W. MARTIN

LOUISIANA STATE UNIVERSITY, 1525

Distribution and population dynamics of the wood duck. **F. W. MARTIN**

LOUISIANA STATE UNIVERSITY, 1551

Monthly availability and use of browse plants by deer in bottomland hardwoods. **R. E. NOBLE**

UNIVERSITY OF MAINE, 5005

Relationships between white-tailed deer and forest vegetation. **S. D. SCHEMNITZ and F. F. GILBERT**

UNIVERSITY OF MASSACHUSETTS, 12

Man-animal interactions in the northeastern forest environment. **J. S. LARSON**

MICHIGAN STATE UNIVERSITY, 982

Ecology of shrubs with high wildlife food and aesthetic value. **L. W. GYSEL**

UNIVERSITY OF MINNESOTA, 17-85

Effect of small mammals on forest reseeding.

J. R. BEER

UNIVERSITY OF MONTANA, 3002

Impact of logging on the elk population in the sapphire range of western Montana. **R. R. REAM**

UNIVERSITY OF NEW HAMPSHIRE, 8
Energy requirements of deer in natural habitat.
W. W. MAUTZ

NEW YORK-STATE COLLEGE OF FORESTRY
AT SYRACUSE UNIVERSITY, 904-1-5
Deer habitat studies. D. F. BEHREND

STATE UNIVERSITY OF NEW YORK, 904-3-1
The chemistry of aquatic plants. R. T. LaLONDE

NORTH CAROLINA STATE UNIVERSITY, 4026
Forest wildlife studies-gray squirrel.
F. S. BARKALOW, JR.

UNIVERSITY OF RHODE ISLAND, 953
Movements of deer related to forest alteration.
J. KUPA

UNIVERSITY OF RHODE ISLAND, 955
Wildlife telemetry in forest environments.
E. F. PATRIC and R. W. SERENBETZ

UNIVERSITY OF TENNESSEE, 3
*Quail management on forest and associated lands in
west Tennessee.* R. W. DIMMICK

UNIVERSITY OF TENNESSEE, 11
*Physiological response of wildlife to different forest
and associated habitats.* M. R. PELTON

UNIVERSITY OF TENNESSEE, 12
*Ecology and behavior of the black bear in the Great
Smoky Mountain National Park.* M. R. PELTON

UNIVERSITY OF VERMONT, 7
*Habitat management and population dynamics of
wood ducks, Aix sponsa (L.).* R. M. FULLER

UNIVERSITY OF VERMONT, 19
*Seasonal carrying capacity of spruce-fir-northern
hardwoods for deer in Vermont.*
T. W. HOEKSTRA

VIRGINIA POLYTECHNIC INSTITUTE, 636121
*Effects of selected disturbance treatments in
oak-hickory stands on deer browse.*
B. S. MCGINNES and H. S. MOSBY

VIRGINIA POLYTECHNIC INSTITUTE, 636136

*Simulations of forest game population structure and
dynamics.* R. H. GILES

VIRGINIA POLYTECHNIC INSTITUTE, 636153
*A model for improving allocation of wildlife
management funds applied to deer management.*
E. F. BELL

WEST VIRGINIA UNIVERSITY, 7
*Use of sonagram analyses as a possible technique for
censusing game birds.* D. E. SAMUEL

UNIVERSITY OF WYOMING, 70
Ecology and carrying capacity of summer elk range.
A. A. BEETLE and MORTON MAY

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Chapter 2

SILVICULTURE

Silviculture has been defined as "the art of producing and tending a forest; the application of the knowledge of silvics and the treatment of a forest; the theory and practice of controlling forest establishment, composition, and growth." Thus, silvicultural research is intended to solve practical problems in the producing forest. As more funds for forestry research become available, the level of refinement in technique and apparatus can be advanced to provide more complete and dependable solutions to the problems of producing more wood and services per unit of land to satisfy the rising demand for these resources.

BIOLOGY, CULTURE, AND MANAGEMENT OF FORESTS AND TIMBER-RELATED CROPS

Research Problem Area 111b

Culture and management are directed at producing adequate supplies at reasonable cost, by methods that harmonize with other forest uses. For the 40 important commercial timber types in the United States, it is necessary to develop techniques for intensive culture on the most accessible and productive sites; and methods for combining timber culture with other uses on the remaining sites. The major job is to find out how to convert wild forests to managed forests of better species, higher quality, and faster growth in the shortest time and at least cost. Each type, including Christmas trees, has distinctive silvicultural characteristics. Research devices improved cultural techniques for the more than 130 commercial timber species, and better methods for forecasting growth and quality changes in relation to management practices, thus providing the basis for selection of economic alternatives.

CALIFORNIA—HUMBOLDT STATE COLLEGE, 12
Regeneration of redwood following selective cutting.
E. W. PIERSON

With the cooperation of local timber companies, 70 tracts of selectively logged areas were examined according to the sampling design. It was difficult to find truly selectively cut areas with respect to the percentage remaining. All areas have had activity on them since the initial cut and, in some cases, all volume has been removed. However, regeneration on all these areas is a result of a selectively harvested stand. Because of this periodic activity, the term "serial" selection is used in this project. Data from this initial research will be statistically analyzed at a later date.

CALIFORNIA—HUMBOLDT STATE COLLEGE, 20
Acceptable stocking levels for managed coniferous stands.
D. L. ADAMS

A regression equation describing the lower levels of full-site utilization was developed. This equation, derived from the crown spread of open-growth trees, is based on the assumption that crown area is indicative of root spread—an assumption which will be investigated further.

Equations based on the culmination of per acre cubic volume growth on various sites and for various average stand diameters are being developed which

may adequately define the upper limit to the acceptable stocking range.

UNIVERSITY OF DELAWARE, 759
Nutrition and management of woodland trees of ornamental value.
C. W. DUNHAM

The growth, fruiting, and regeneration of American holly (*Ilex opaca*) is under study in two southern Delaware woodlands: one dominated by loblolly pine and the other by mixed hardwoods. Both woodlands were cut over in the thirties and, in both, holly constitutes slightly more than 10 percent of the present total and seedling populations. Comparison studies have been made in a planted holly orchard.

Nutritional responses of the planted holly have been determined by analyses of the first normal leaf above a fruit cluster. Greatest differences in leaf composition exist in newly matured leaves of the first flush of growth. Nitrogen far outweighs other nutrients in its effects on growth and composition of holly.

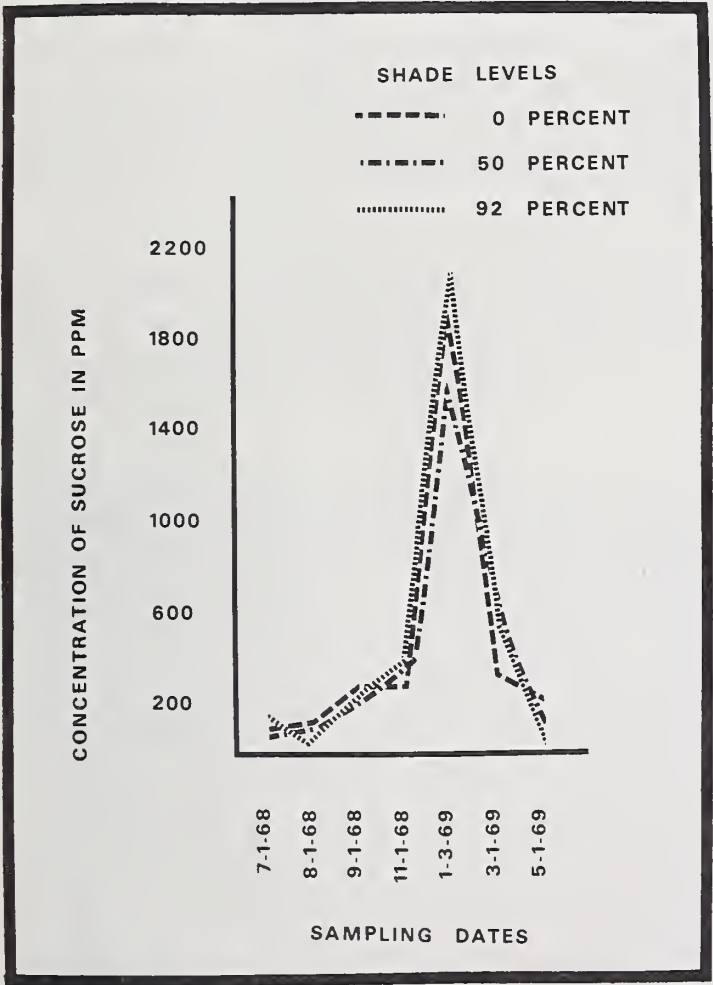


Figure 22. Sucrose concentration in holly leaves, not affected by shade level, varies with season.

Light effects have been simulated by constructing cages of saran cloth with normal light intensity reduced by 50 and 92 percent. Plants of the same age and same clone were planted in each woodland to study growth and fruiting variables. Plants in full sun fruit annually; plants in reduced light fruit erratically and never with the same number of fruits as those receiving more light. There appears to be a cycle in the fruiting of wild plants in that many more fruits are produced in some years than in others. The two woodlands under study do not appear to exhibit the same cycle.

Sucrose, fructose, and glucose show a dramatic increase in the leaves in the late fall and winter, corresponding to the onset of dormancy, and a rapid decline at bud break. There did not appear to be a significant difference in the sugar content of shade and sun leaves, which would suggest that the soluble sugar level is independent of total carbohydrate reserves (fig. 22). The relationship, if any, to fruiting cycles and total carbohydrates is under study.

SOUTHERN ILLINOIS UNIVERSITY, 67-R-014
Native trees for parks.
D. R. McCURDY

The research resulted in a guide that will prove invaluable to park planners, landscape architects, and home gardeners. Common names as well as scientific names are used, and guides for achieving desired effects as well as for identifying tree characteristics can be easily used by home gardeners or amateur botanists. Characteristics of 50 trees native to the area are given in detailed summaries which note their specific suitability for the various purposes which they may serve. Along with brief general descriptions of tree characteristics, the book contains copious illustrations and tabular summaries and comparisons of shape, size, leaf forms and colors, bark, flowers, fruit, longevity, roots, self-pruning and sprouting potential, shade tolerance, insect and disease susceptibility, site requirements, and soil conditions.

LOUISIANA STATE UNIVERSITY, 1237
Producing and marketing Christmas trees in Louisiana.
C. W. BREWER

Results of a study to determine the best time to prune Virginia and spruce pines show no single pruning will enable a grower to produce satisfactory

numbers of merchantable Christmas trees (fig. 23). The best percentages of 5-year-old trees U. S. Grade 2 or better, for three treatment times, are 44 percent in April-May for Virginia pine and 24 percent in April-May for spruce pine. Pruning in April-May produced more premium-grade trees, but these were only 3 percent of the total treated.

Results from a herbicide study, using Paraquat, Dalapon, Dalapon-Amazine combined, and Dalapon-Simazine combined, indicated single applications of Dalapon-Amazine, 5 and 7 pounds per acre, respectively, and Dalapon-Simazine, 5 and 3 pounds per acre, respectively, provided excellent kill of grasses and broadleaf weeds for 1½ months. Combination treatments were better than the control. No treatment significantly affected growth of 1-year-old Virginia and spruce pine Christmas trees. Data on Virginia pine previously tested with these herbicides used alone in three applications show little treatment differences due to any residual effect, on growth or survival from the control.

Data from a planting for optimum cultural treatment of Christmas trees show 1089 Virginia pine had 82 percent survival, while 1089 spruce pine had 74 percent survival. Average height of both species was 1.1 feet after 1 year.



Figure 23. Five-year-old Virginia pine Christmas trees pruned twice in fourth and fifth growing seasons.

LOUISIANA TECH UNIVERSITY, 4

Nuclear methods for determining site index.

J. KUPRIONIS and C. HOBGOOD

Field work and collection of data were completed on this project on 30 June 1971. However, computer calculations were left unfinished until the present time when they are being completed under State appropriation funds. Difficulties that have arisen in computer programming are in the process of being resolved.

MICHIGAN TECHNOLOGICAL UNIVERSITY,
2-3110

Stand structure and quality of selective versus clear-cut northern hardwoods. V. W. JOHNSON

Species composition of the northern hardwood study areas was adversely affected by the heavy diameter limit cuttings as well as by the commercial clear cut. Light-to-moderate cuts maintained good species composition with a high percentage of sugar maple evident in the residual stands. Diameter limit cutting permitted no control of the diameter distribution and resulted in stands which were overstocked in the smaller diameter classes and understocked or completely deficient in the larger ones. Stands marked for cutting by means of individual tree selection, on the other hand, afforded complete control over the size class distribution and should, after a few more harvests, exhibit a well balanced stand structure.

Diameter limit cuttings also allowed no control of the quality composition of the residual stands. Defective and low quality trees were left to grow until they reached a prescribed diameter, thus occupying space needed to produce high quality timber. All the diameter limit study areas contained trees of low quality. Reduced quality of the stand is attributed to cutting defects and branching in the lower bole. In addition, portions of the heavier cut stands were occupied by brush or grassy openings 14 years after the stand was cut. The quality composition of the sawtimber derived from selectively marked study units was better than that on the diameter limit- and clear-cut study units.

Based on the results of this study, it appears that management of northern hardwoods by individual tree selection offers the forest manager the best opportunity to control the residual stand structure and quality composition. Diameter limit-cutting methods, although much easier to apply, sacrifice much of this control.

UNIVERSITY OF MINNESOTA, 19-019

Development of hazel understories in northern Minnesota forests.

J. C. TAPPEINER II and B. A. BROWN

Beaked hazel invades red pine stands by seeding, and a seedling-young clone stage occurs before dense, continuous undergrowth is formed (fig. 24). Seed production, germination, and seedling survival show that hazel is well adapted to the seeding process. Seed production for 3 years on 10 areas has averaged over four seeds per stem per year. Over 95 percent of the seed was taken by predators—the principle means of dispersal. Field germination of 1969 seed occurred over 2 years: 41 percent the first, 38 percent the second. First year seedling survival averaged 90 percent where there was no rodent predation, the principle cause of mortality. Rodent activity appears erratic: they took 0-95 percent (average 30 percent) of the seedlings after germination. In the second year when predation ceased, seedling mortality was less than 5 percent. Using fire and herbicides on dense hazel resulted in temporary control and often an increase in stem density. Seedlings and young clones are susceptible to light burns (75 percent mortality) and $\frac{1}{2}$ to 1 pound of 2,4-D (90 percent mortality). Thus, the development of dense undergrowth can be prevented. Biomass and nutrient distribution in hazel undergrowth in five conifer stands has been determined. In jack pine, 50- to 70-year-old hazel (5-10 percent of the biomass) may contain 10-20 percent of the nutrients in the vegetation.



Figure 24. Typical dense hazel undergrowth in 150-year-old red pine stand.

OKLAHOMA STATE UNIVERSITY, 1360

Control of undesirable woody plants: The effect on forest and native grass development and wildlife habitat.

T. H. SILKER, H. ELWELL, and K. JACOBS

Two successive aerial sprays of ester of 2, 4, 5-T generally have been found satisfactory for controlling most undesirable hardwoods over-topping pine and for releasing native grasses and herbaceous vegetation. Winged elm, red cedar, and associate brush-type species such as red haw and tree huckleberry are quite resistant to standard sprays, however. Subsequent development of these species has so clogged the ground that native grass development is seriously limited on considerable acreage. Federal cost-sharing in chemical treatment is not now permitted where resistant species frequency is high, and it will not be allowed until effective treatments are determined.

MS Project 1360 was initiated in 1963 to study two treatments to increase percent kill on resistant undesirable hardwoods: (1) Chemical spray additives, and (2) two prescribed burns. Treatments are evaluated for effect on: (a) shortleaf pine and native grass release and development, and (b) wildlife habitat (primarily white-tail deer) (fig. 25).

Trends show the complementary treatments have had the following results: (1) Adequately released native grasses and understory pine stems, (2) reduced oak mast production and browse availability on preferred hardwoods such as hickory, (3) produced fire-girdled species resistant to chemical sprays and induced resprout growth that materially increases available browse volume, and (4) significantly increased herbaceous species that are highly desired summer browse, from the second through fifth year.

Some 75,000 acres per county have been chemically sprayed in some eastern Oklahoma areas, per annum, to release native grasses and effect better pine development. Ranchers and forest landowners are beginning to lease access rights to white-tail deer hunting.

PENNSYLVANIA STATE UNIVERSITY, 1816

A short-term wood fiber production system.

T. W. BOWERSOX, W. W. WARD, and
W. K. MURPHEY



Figure 25. Spring and early summer browse use of hickory leaves to 4-foot height by white-tail deer. This is heavier than normal use on selected plants. Normal use is approximately one-third this intensity.

The opportunity to produce substantial amounts of wood fiber in a short period of time is excellent when hybrid poplars are planted at corn-like spacings. Plantations of promising clonal varieties have been established at three locations in central Pennsylvania to evaluate the potential of a short-term fiber production system.

Yields from 4-year-old plantation of Clone NE-388, replicated in time and space, indicate that the greater number of smaller trees at the $\frac{1}{2}$ ft x 2 ft spacing are currently out-producing the larger trees at the 1 ft x 2 ft or 2 ft x 2 ft spacing. However, initial estimates from 5-year-old trees indicate that the production from the greater spacing will equal or exceed the lesser spacing. Four-year average annual production of the $\frac{1}{2}$ ft x 2 ft, 1 ft x 2 ft, and

2 ft x 2 ft was 2.8, 2.3, and 2.1 tons per acre of oven-dried, main stem wood. Average annual 5-year production was 2.7, 2.9, and 2.3 tons per acre of oven-dried, main-stem wood for the $\frac{1}{2}$ ft x 2 ft, 1 ft x 2 ft, and 2 ft x 2 ft spacings.

UNIVERSITY OF VERMONT, 2

Effect of leader damage on the growth of planted conifers.
T. L. TURNER

Comparisons of undamaged and damaged plantation-grown white pines, 11 to 40 years old, indicate that attacks by white pine weevil do not seriously affect site index determinations for the stands sampled. This population, however, was limited by sampling criteria to less heavily damaged plantations. For these stands, the average height loss is so small that any adjustments of site index would be minimal.

More heavily damaged stands are probably more subject to height loss that might affect site index. If these stands are of any value, determination of site index is a real problem. It is almost impossible to find and define a normal (undamaged) population against which to compare height differences. If site index is important in these stands, some other means of site evaluation should be used, since accurate height adjustments to reflect weevil damage cannot be made at present.

UNIVERSITY OF VERMONT, 10

Influence of environment on chemical weed suppression in Christmas tree plantations.

T. R. FLANAGAN and M. L. McCORMACK, JR.

Satisfactory weed suppression with excellent tree responses, especially from balsam fir, has been accomplished using simazine herbicides as granules or wettable powder. Common hayfield grasses such as blue grass, redtop, timothy, and sweet vernalgrass have been controlled through two growing seasons where rates of 8 to 12 pounds of active chemical have been applied per acre treated. Simazine-resistant weed species occurring most frequently are dandelion, buckhorn plantain, and sheep sorrel. Laboratory evaluation of transpiration and carbon dioxide uptake indicates that these resistant species are not serious competitors with the planted trees within simazine-treated bands.

Simazine and simazine-atrazine combinations have controlled 80 to 95 percent of the sod competition. Such treatments consistently support new plantings with tree mortality losses of less than 10 percent. Balsam fir responses include increased terminal growth, longer needles, darker green foliage, increased numbers of larger buds, better branch structure, and increased leader diameters when compared with untreated trees. Timing of applications is important, and there is need for suppression of woody weeds, such as spirea, which are also present on some sites. Effectiveness of a given herbicide rate decreases with increased soil moisture, organic matter, and weed density on sites treated. Simazine residues in the soils for a 3-year period following treatment are presently being evaluated.

UNIVERSITY OF WYOMING, 940

Variation and ecology of aspen. A. A. BEETLE

In Wyoming, popular prejudice in favor of large populations of a single herbivorous mammal—the elk—has sacrificed in a three-county area a whole plant community—the aspen deciduous forest. While neither the elk nor the aspen is in danger of extinction in this area, the natural synecological presence of either in a community sense has ceased to exist.

In Teton County, Wyoming, study plots involving exclosures on Berry Creek, the Gros Ventre River, Uhl Hill, the National Elk Refuge, Grey's River, and Black Tail Butte, as well as a series of stands on Pacific Creek, have been used to study the ecology of aspen. For the sixth year, the individual life histories of mature trees and hundreds of saplings have been recorded.

The studies have strengthened the following conclusions:

- (1) Aspen has existed as a climax community in the Jackson Hole area.
- (2) Aspen needs only protection from browsing to regenerate.
- (3) The history of fire in Jackson Hole is not a principal cause of the deterioration of aspen stands in Jackson Hole.

- (4) The primary cause of aspen deciduous forest deterioration is excessive utilization by elk.

ADDITIONAL PROJECTS

CALIFORNIA—HUMBOLDT STATE COLLEGE, 18
Sowing Lupine for better seedling growth and development of planted redwood and associated species. E. W. PIERSON and D. A. THORNBURGH

CALIFORNIA—HUMBOLDT STATE COLLEGE, 23
Evaluation of present commercial thinning practices in 50- to 80-year-old stands of young-growth redwood (Sequoia Sempervirens) in Humboldt County, Calif. R. A. HURSEY

UNIVERSITY OF GEORGIA, 17
Crown growth and wood formation in loblolly pine. J. R. BECKWITH

UNIVERSITY OF GEORGIA, 22
Quick coppicing hardwoods for fiber yield. J. T. MAY and K. STEINBECK

UNIVERSITY OF IDAHO, 19
Evaluating pocket gopher damage to forest trees in Idaho. K. E. HUNGERFORD

KANSAS STATE UNIVERSITY, 721
Hardwood planting on strip-mined lands. W. A. GEYER

LOUISIANA STATE UNIVERSITY, 1266
Competition in slash, loblolly pine plantations. T. D. KEISTER

LOUISIANA STATE UNIVERSITY, 1500
Evaluation of the use of tubelings in regenerating southern pine. B. H. BOX

LOUISIANA STATE UNIVERSITY, 1547
Thinning dense young loblolly pine stands with granular herbicides. T. D. KEISTER

MICHIGAN STATE UNIVERSITY, 984
Optimizing site conditions for establishment and growth of high quality black walnut. D. P. WHITE and G. SCHNEIDER

UNIVERSITY OF MINNESOTA, 19-018
Evaluation of tubelings for forest regeneration.
B. A. BROWN and A. A. ALM

NORTH CAROLINA STATE UNIVERSITY, 4030
*Bedding, ditching or furrowing, and fertilizing effects
on growth of pines on wetland sites.* T. E. MAKI

NORTH CAROLINA STATE UNIVERSITY, 4018
Fertilization and irrigation of seed orchards.
C. B. DAVEY

OHIO AGRICULTURAL RESEARCH AND
DEVELOPMENT CENTER, 1
Effects of fertilizers on sugar maple and tulip poplar.
J. P. VIMMERSTREDT

OHIO STATE UNIVERSITY, 10
*Production of plantation grown Christmas trees in
Ohio.* J. H. BROWN

SOUTH CAROLINA-CLEMSON UNIVERSITY,
789
Irrigation and fertilization on upland forest.
N. B. GOEBEL

SOUTH CAROLINA-CLEMSON UNIVERSITY,
706
Timing harvest in even-aged timber stands.
J. R. WARNER

UNIVERSITY OF TENNESSEE, 2
Fertilizer and irrigation effects on tree growth.
E. R. BUCKNER

UNIVERSITY OF TENNESSEE, 14
*Effect of seedling root deformation on growth and
allocation of auxins.* F. W. WOODS

TEXAS A&M UNIVERSITY, 1673
Intensive culture of hardwoods.
R. G. MERRIFIELD

UNIVERSITY OF VERMONT, 1
Spruce and balsam fir Christmas-tree culture.
M. L. McCORMACK

UNIVERSITY OF VERMONT, 8
Soil growth wood quality of birch.
P. R. HANNAH

VIRGINIA POLYTECHNIC INSTITUTE, 636134
Dry matter production models of forest.
H. A. I. MADGWICK

UNIVERSITY OF WASHINGTON, 25
*Relations of wildlife populations to Douglas-fir forest
characteristic and protection.* R. D. TABER

UNIVERSITY OF WYOMING, 71
*Vegetative history and boundary stability of park
areas in Medicine Bow National Forest.*
P. C. SINGLETON and L. I. PAINTER

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IMPROVEMENT OF RANGE RESOURCES

Research Problem Area 112

Research seeks to maintain and improve the forage-producing capacity of rangelands. Native range in the United States includes over 900 million acres. It represents a continuum of sites and productivity potential from the deserts of the Southwest to the prairies of the Midwest and from the sea-level grasslands of Florida to the alpine herblands of the high Rockies. Rangelands are important as a source of feed for beef cattle and sheep, in watershed protection, soil stabilization, wildlife habitat, and recreation.

SOUTH DAKOTA STATE UNIVERSITY, 561

Tree encroachment into Black Hills grassland: Ecology and management options.

F. R. GARTNER, W. W. THOMPSON, and
E. M. WHITE

Prescribed burns were conducted in April and May 1971 to study the use of fire for control of encroaching and thickening ponderosa pine in grasslands. (figs. 26 and 27). In areas grazed lightly, headfires were more efficient than backfires for eliminating small pine seedlings. Poor seedling control was obtained where inadequate fuels were present due to excessive grazing. Fire was used in a residential



Figure 26. Ponderosa pine encroachment into grasslands surrounding the Black Hills is evident and increasing yearly.



Figure 27. A rather cool backfire was successful in reducing fuel accumulation by 50 percent in this foothills area. Pine seedlings less than 12 inches in height were almost completely eliminated in the open grassland areas.

area in the pine-grass foothills to reduce the wildfire danger. Pine seedling mortality and fuel reduction were 90 percent and 50 percent respectively.

Another burn, designed as a preharvest treatment to reduce excessive pine reproduction, resulted in nearly complete elimination of pine seedlings and 70 percent reduction of flash fuels. Litter accumulation is being studied, and a site has been prepared to determine the effect of decaying pine slash and pine reproduction on forage production following a timber harvest.

Surface soils and litter from six pine-grassland sites were subjected to simulated fire temperatures to determine N, P, K release (lab analyses accomplished under cooperating project S-409).

Forage production data from a pine thinning study in Custer State Park showed a large increase over 1970, largely because of above normal rainfall. Production in the unthinned control showed no response to increased precipitation.

A public field tour, featuring a leading authority in the use of control burning, was conducted in late April to create public awareness, interest, and support of controlled burning research.

UNIVERSITY OF MONTANA, 210-0603

Grazing use and forage yield of forest land in western Montana. M. S. MORRIS and L. EDDLEMAN

Six clear cuts in the subalpine fir forest ranging from 1 to 17 years of age were examined. Aspect, soils, treatment, and vegetation were matched as closely as possible. Understory vegetation was primarily *Vaccinium membranaceum*, *Xerophyllum tenax*, *Pachistima myrsinites*, and *Spiraea betulifolia*. Logging scarification and burning slash reduced plant cover 80 to 90 percent. Rate of vegetal development was slow on both burned and scarified areas. The 17-year-old clear cut had only 50 percent as much ground over as that provided by the adjacent forest understory. Greater diversity of species was achieved on the scarified areas than on burned areas.

Although scarified areas went through a general succession of perennial forbs to grasses and shrubs, the burned areas went through a succession of annual forbs to perennial forbs and had progressed no further. Some resident species survived treatment, some were lost to the flora, and many species were invaders. The canopy cover of the four dominant species was reduced by more than 90 percent in the clear cuts, 42 percent in the understory to less than 3 percent in the clear cuts, and no significant recovery was evident. Grasses, primarily *Calamagrostis rubescens*, increased in cover on both burned and scarified areas. The highest cover value (4.7 percent) was on the 17-year-old clear cut, while the forest understory cover averaged only 0.3 percent.

OKLAHOMA STATE UNIVERSITY, 1161

Artificial regeneration of shortleaf pine.

T. H. SILKER

This project was initiated in 1963 to determine the least site biologically and economically suitable for the introduction of shortleaf pine on rocky, tension-zone environments of the Oklahoma Ouachita Highlands province.

Undesirable overstory hardwoods were deadened by chemical injection to simulate aerial chemical spray treatment. One pound per acre of bird and rodent-repellent treated pine seed was sowed in late-winter, for 3 years, on post oak-blackjack oak, post oak-blackjack oak-hickory, and hickory-red oak sites. Premium-grade 1-0 pine seedlings were likewise hand-planted for 3 years on similar sites.

Direct-seeding gave adequate stocking only one out of three years, but seems the most practical means to establish pine on rocky Hector-Pottsville soils. These sites limit the use of planting machines and initial pine growth does not seem sufficient to offset establishment and carrying-charge costs.

Supplemental study of native stands shows there is definite correlation between shortleaf pine site indexes and associated plant indicators. Mean site index of pine associated with blackjack oak-hickory, hickory-tree huckleberry, and hickory-red oak sites at the western extremity of the pine belt (<46 inch precipitation) was 50.7, 54.2, and 60.7 feet, respectively. A minimum pine site index of 60 is indicated for economically feasible management in this zone. Hickory-tree huckleberry sites with a pine site index as low as 55 could be economically manageable for pine when the rotation length is shortened to 20 years and fixed scale value schedules are used.

ADDITIONAL PROJECTS

NORTHERN ARIZONA UNIVERSITY, 5
Range forage on parks in ponderosa pine.

L. D. LOVE

UNIVERSITY OF CALIFORNIA, 2500
Ecological adjustments of range plant populations to use and environment.

H. F. HEADY

UNIVERSITY OF IDAHO, 12
Effects of livestock trampling on plant growth and forage productivity.

L. A. SHARP

UNIVERSITY OF IDAHO, 18
Prescribed burning influences on the forage value of key big game browse species.

K. E. HUNGERFORD

UTAH STATE UNIVERSITY, 670
Range plant foliage removal effects on soil moisture regime.

G. B. COLTHARP

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TREES TO ENHANCE RURAL AND URBAN ENVIRONMENT

Research Problem Area 905

This research provides some of the scientific knowledge required to maintain or improve the quality of the rural and urban environment, and to enhance natural beauty through special-purpose tree planting. Technological change is multiplying the need for special tree planting to screen junkyards and highways, suppress noise, slow the movement of dust and debris, and to provide trees for shade, beauty and shelterbelts to protect crops, animals, and farmsteads. Research is needed to find species and techniques so

that trees can survive smoke and air pollution, compacted soils, deficient or excess moisture, and other adverse conditions. The end product of concern in this research is a standing tree to enhance the environment.

UNIVERSITY OF NEBRASKA, 20-023

Windbreak shelter effects.

W. T. BAGLEY and N. J. ROSENBERG

The microclimate of sheltered zones was studied in a lysimeter field with slat fences providing the shelter and in fields protected by two-row windbreaks, arranged in a tic-tac-toe pattern. Water use efficiency of soybeans and wheat was also studied.

Simultaneous measurements of microclimate and evapotranspiration by soybeans were made in the open and in the shelter of a slat fence of 50 percent density. Two precision lysimeters were used to determine the accuracy of the Bowen Ratio Energy Balance in wind shelter. The Bowen Ratio was then applied in the tree shelterbelt study. Microclimatic parameters and energy balance were measured in the open and at 2-, 4-, and 8-foot heights to the lee of the shelterbelt over ripening dryland wheat. The shelterbelt was planted in 1966 and consisted of alternating cottonwood and eastern red cedar in one row and eastern red cedar and Scotch pine in the second row. The tree heights were about 1.5 meters for the conifers and 4 meters for the cottonwood. This combination provided a very dense lower story and a very permeable upper story.

The slat fence reduced wind speed by approximately 40 percent at four heights and increased wind shear which caused a neutralizing effect on atmospheric stability. The tree shelterbelt decreased wind shear because of difference in structure between the lower one-third and the upper two-thirds of its height. It was most effective in reducing wind speed when winds were light and the angle of incidence with the belt was slightly oblique. Drag coefficients indicated that the tree shelterbelt was most effective during periods of atmospheric stability and least effective during unstable conditions. Surface boundary layers were thin in the lee of the tree shelterbelt and thicker in the lee of the slat fence.

Exchange coefficients, which were lysimetrically determined, were reduced in the lee of both windbreaks. Exchange coefficients, determined by Bower Ratio Energy Balances agreed with lysimetric observations.

Absolute air temperatures were greater and temperature gradients were more strongly lapse in shelter. During periods of advective inversion, the slat fence caused a decrease in intensity of the inversion or a change to lapse profiles over the irrigated soybeans. Vapor pressure in air and lapse vapor pressure gradients increased more in the lee of the slat fence over irrigated soybeans than in the lee of the tree shelterbelt over dryland ripening wheat.

Evapotranspiration of the soybeans, measured by precision lysimeters, was significantly reduced by the slat fence. The maximum reductions occurred during periods of strong sensible heat advection when the slat fence reduced the amount of sensible heat flux to the canopy. Bowen Ratio determinations showed reduced latent heat flux in the lee of the tree shelterbelt.

CO₂ concentration gradients were increased in the shelter of the slat fence, but little consequent effect on CO₂ flux could be detected. Increased photosynthetic opportunity occurred because of reduced stomatal closure in the shelter of the slat fence. Water-use efficiency was improved by wind shelter in the irrigated soybean crop. Evidence suggests that tree shelterbelts will also increase water use efficiency in dryland situations.

NORTH DAKOTA STATE UNIVERSITY, 12-1

Shelterbelts in North Dakota.

E. P. LANA

Public interest in the growth of conifers on the "Tree Establishment Study" plot in the arid southwest of North Dakota (one of three replicated sites) has resulted in an increase of the experiment in that area. Ten species of conifers were planted in 5 ft x 5 ft mulched plots. The mulch used was 6 mil polyethylene as a check and a fiberglass blanket; trees were fertilized and watered.

Field studies on the behavior of an *Opheltes* sp. parasite of *Cimbex americana* have been completed.

Preliminary analysis of the data indicates the efficiency of this parasite to be reduced severely by moderately high temperatures. Four shelterbelts in the State have been studied in detail to provide information on the effectiveness of *Opheltes* as a natural control factor.

Black Hills spruce and ponderosa pine plots established in 1970 were severely winter-killed. Roots of ponderosa pine seedlings inoculated with five species of fungi developed dichotomously branched roots indicative of mycorrhizae only after growing for 8-12 months in the greenhouse. Fewer mycorrhizae developed on inoculated pine in sterile perlite than in sterile soil.

ADDITIONAL PROJECTS

CONNECTICUT AGRICULTURAL EXPERIMENT STATION, 416

Attenuation of noise by vegetation.

D. E. AYLOR and P. E. WAGGONER

UNIVERSITY OF NEBRASKA, 20-028

Tree breeding. W. T. BAGLEY and D. P. COYNE

NEW JERSEY AGRICULTURAL EXPERIMENT STATION, 257

Effects of environmental stresses on the oak-chestnut forests of Blue Mountain Pennsylvania.

B. B. STOUT

NORTH CAROLINA STATE UNIVERSITY, 4031

Management characteristics of urban forest space.

J. O. LAMMI

SOUTH DAKOTA STATE UNIVERSITY, 475

Selection and propagation of woody plants for the Northern Plains.

D. E. HERMAN

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Chapter 3

FOREST HARVESTING AND ENGINEERING

Forest harvesting and engineering involve men, machines, and techniques for felling and transporting harvested trees to processing points. Other topics include degree of utilization and forest waste material, intermediate storage of wood in the forest, and performance measurements. Chronic problems of safety, work performance, and production efficiency for woods workers and equipment are examined to systematically determine least-cost methods of producing wood. Increasing concern for environmental protection has focused attention on methods of harvesting as they affect soil erosion, vistas, and wildlife and as they create residue disposal problems.

NEW AND IMPROVED FOREST ENGINEERING SYSTEMS

Research Problem Area 302

Improved forest engineering systems can reduce timber harvesting costs, increase and stabilize rural payrolls, reduce accidents, and provide higher returns to industry. Over 100 billion board feet of timber in Alaska and the western States are inaccessible because of the high cost of road construction, steep terrain, soil conditions, and lack of equipment suitable for timber harvesting. In other States, because of the high proportion of small-size timber and the high percentage of defective timber, the economic feasibility of harvesting is limited.

UNIVERSITY OF MASSACHUSETTS, 11

Distance-measure sampling for volume growth.

J. C. MAWSON

Tree growth is a function of growing space. Distance measures are a class of estimators designed to sample for spatial distribution or growing space. Regression equations included radial and volume growth as the dependent variables. Distance to first and second tree from a sample tree and various "competition indices"

have been calculated. Distance to the second closest tree accounts for about 40 percent of the variability in cubic foot volume growth. This varies little with site index (50-year base). Three of the 10 competition indices used accounted for a significant proportion of the variability, although the actual percentage was small. Work is continuing with the white pine data to produce equations whose coefficients will be accurate for eastern white pine and whose variables will indicate the direction to go with other species.

ADDITIONAL PROJECTS

LOUISIANA STATE UNIVERSITY, 1444

Development of timber harvesting systems for the southeastern United States.

R. W. McDERMID

MICHIGAN TECHNOLOGICAL UNIVERSITY, 2-3310

Pulpwood skidding time analysis in the Keweenaw Peninsula, Michigan.

H. M. STEINHILB

OREGON STATE UNIVERSITY, 00870

Relationship of timber harvesting systems to logging residue.

H. A. FROELICH

Effect of high vacuum pumping systems on the sugar maple tree and its sap.

F. M. LAING and E. L. ARNOLD

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Chapter 4

FOREST INJURIES AND PROTECTION

Research described in this chapter deals with well-known sources of damage to forests, including fires, insects, and diseases, and unusual sources such as avalanches and volcanic ash. Research concerned with techniques for protecting forests from injuries is also discussed.

CONTROL OF INSECTS AFFECTING FORESTS

Research Problem Area 201

Insects exact a heavy toll of young trees each year, killing many and damaging and reducing the growth of surviving trees. Wildlife habitat is changed, and fire danger is increased. Forest insect research can provide the information needed to reduce the continuing losses to forests and forest products, including Christmas trees. A sustained flow of new information provides the basis for safe, effective methods of control.

UNIVERSITY OF ARKANSAS, 611

Control of pine sawflies in Arkansas with special reference to the use of biological control age.

L. O. WARREN and J. P. FULTON

The nuclear polyhedrosis virus of the Arkansas pine sawfly was purified and characterized on the electron microscope (fig. 28). The polyhedron consisted of single nucleocapsids bounded by an envelope and randomly occluded in a crystalline protein matrix. Nonoccluded virions were present in the nuclei of infected cells early in the disease, but polyhedra were not present. Late in the disease, the nuclei of infected cells contained free virions as well as numerous polyhedra. Associated with the virogenic stroma were symmetrical arrays of empty capsids; some capsids contained a nucleoprotein core.

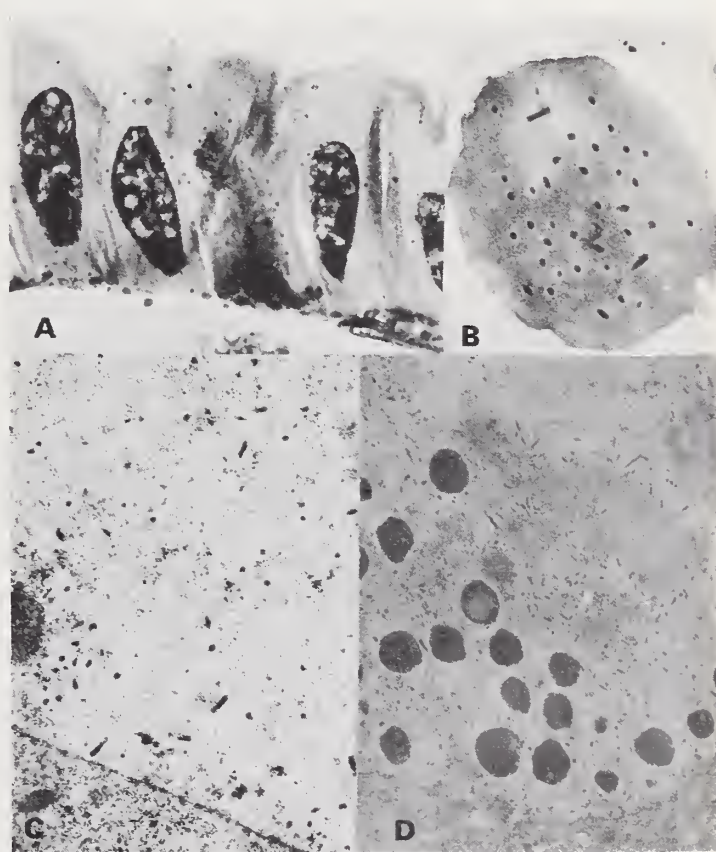


Figure 28. A—Midgut epithelial cells infected with nuclear polyhedrosis virus. B—Section of polyhedron of loblolly pine sawfly virus. C—Nucleus in early stage of virus infection with only virions present. D—Nucleus in late stage of virus infection with both virions and polyhedra present.

The nuclear polyhedrosis virus was effective against larvae in the field at a spray concentration of approximately 1×10^7 PIB/ml. Methomyl (Lannate)

was extremely effective against the sawfly. Excellent control was achieved at 0.50 ounces, 90 percent W.P./100 gallons water.

UNIVERSITY OF IDAHO, 17

*Influence of natural and manipulated stand characters on *S. ventralis* population and damage levels.*

J. A. SCHENK

Two areas of the *Abies grandis*/*Pachistima* were selected for study. Three treatments—two levels of thinning and a control—were established in two study sites, and each treatment area was sampled by means of 10 1/10-acre plots (fig. 29). Detailed data on the tree stand and its condition were obtained, including data on disease, defects, cone production, and insects present (fig. 30). The number of trees attacked by *Scolytus ventralis* and occurrence of other forest pest species were also recorded. Detailed studies of *S. ventralis* will begin next year.

UNIVERSITY OF MAINE, 5013

Biology and ecology of hardwood defoliators.

D. E. LEONARD and P. W. SCHAEFER

Two introduced hardwood defoliators are being studied—the gypsy moth and the brown-tail moth. These related insects have a similar history of rapid spread throughout the Northeast after their



Figure 29. Typical tree and ground vegetation in an *Abies Pachastima* treatment area of northern Idaho, 1970.



Figure 30. Fir engraver attacks in grand fir in northern Idaho.

accidental introductions. The brown-tail moth has since declined to such an extent that it is now found only on several islands in Maine, and on coastal dunes in Cape Cod, Mass. Mortality factors presently restricting brown-tail moth populations may provide some clues to its decline. Several aspects of the ecology of the brown-tail moth were studied, including characterization of its habitats, amount of survival of overwintering larvae, parasitoid complex in several populations, and adult dispersal.

The gypsy moth is not a major problem in the northern parts of its range, in part because of less favorable forest types. Winter temperatures also are a major factor. In a population exposed to the harsh temperatures of the 1970-71 winter, only eggs covered with snow survived; about 85 percent of all eggs died. Parasitoids may also be reducing the severity of outbreaks in Maine, and various life stages of gypsy moth are being sampled to determine which parasitoids occur and their importance.

Population quality is an important factor in regulating the numbers of gypsy moths. When a population reaches a high density, the quality of the population is affected, triggering behavioral and nutritional changes which cause the insect to disperse. Prevention of this qualitative change by maintaining populations at low densities could be a feasible pest management approach to control in areas where the gypsy moth has become established.

NEW JERSEY—RUTGERS STATE UNIVERSITY,
425

Low host density population dynamics of the gypsy moth.
F. C. SWIFT

A study was conducted in Yugoslavia to determine the parasites associated with various densities of the gypsy moth, with particular reference to areas in which populations of the gypsy moth had stabilized. Parasite cocoons and puparia were reared from infested hosts and sent to the New Jersey Department of Agriculture. Records were kept on the percentage of parasitism and the species of parasites found in the various study areas. Results in Yugoslavia indicated that *Apanteles liparidus*, *A. melanoscelus*, and *Compsilura concinnata* were associated with low gypsy moth populations; *A. porthetria*, *Exorista larvarum*, *Hyposoter* sp., *Sturmia scutellata*, and *Sturmia* sp. with high host densities; and the occurrence of *A. ocnariae*, *A. solitarius*, and *Carcelia gnave* was independent of host density. Six parasites were sent back to the United States for colonization and further study by personnel at the New Jersey Department of Agriculture. *Hyposoter dispar* was reared out and released near Morristown, N. J., and since has been recovered in other parts of the State. However, its establishment was not related to this release. *Apanteles melanoscelus* is already well established in New Jersey, but the specimens sent back from Yugoslavia seem to differ from the American strain. The Yugoslavian strain is being studied further in the laboratory before release. *Exorista larvarum* is under culture in New Jersey Department of Agriculture laboratories in Trenton. *Apanteles ocnariae* and *Carcelia gnave* could not be reared. There is the possibility that one new species, *Exorista larvarum*, and a new biotype of an established species, *A. melanoscelus*, may be added to the parasite complex of the gypsy moth in New Jersey. Hopefully, this project will aid significantly in the attempt to stabilize gypsy moth populations through biological means.

NEW JERSEY—RUTGERS STATE UNIVERSITY,
436

Metabolism of insecticides by the gypsy moth (Porthetria dispar).

A. J. FORGASH and AHMED SAMI

Work during the past year involved (1) Assisting the New Jersey Department of Agriculture in its program of gypsy moth control through laboratory evaluation of the efficacy of various control chemicals, uniformity of application, potential hazards to parasites, and the insecticide tolerance of different populations of the moth; and (2) conducting basic studies on the biochemistry and toxicology of the moth (fig. 31). Dylox (80 percent ASP) was quite toxic to larvae by topical application or contact; however, it was also highly toxic to five moth parasites. Larvae from five areas in Monmouth County, N. J., were equally susceptible to Dylox and carbaryl. Larvae (reared from eggs) collected in Monmouth County were more tolerant to carbaryl and varied more widely in susceptibility than ones from northern New Jersey. This may be true resistance and should be further evaluated. Many difficulties in the study of Gardona® metabolism have been resolved, enabling identification of three metabolites. There appear to be three or four other metabolites to which structures have been tentatively assigned. Most of these compounds are also present as conjugates. Studies on the insecticide-metabolizing system of the larvae show that microsomal



Figure 31. Dissection of gypsy moth larvae for tissue enzyme studies.

preparations of Malpighian tubules and alimentary tract are much more active than those from fat body in oxidizing NADPH. Addition of 1 percent albumin did not improve the activity. SKF-525A, a standard inhibitor, completely prevented NADPH oxidation at 1×10^{-3} M. Future microsomal preparations will be made primarily from the alimentary tract because of the greater abundance of tissues.

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, 3

Integrated control of the insect and mite pests of pine trees. D. G. NIELSEN

One early May application of oxydemetonmethyl controlled the European pine sawfly, *Neodiprion sertifer* (Geoffroy), and two pine aphids, *Cinara pinea* (Mordvilko) and *E. agilis*, on Scots pine grown as Christmas trees without seriously reducing the kinds and numbers of possible arthropod predators of these pests. Occasionally, a second spray was needed to control a late summer buildup of the spotted pine aphid since arthropod predators did not suppress fall aphid populations enough to prevent economic damage (fig. 32). Apparently, *E. agilis* is more cold resistant than its predators. Long-term studies of the population dynamics of the spotted pine aphid have been initiated with the objective of learning to predict when control measures are necessary.

Insecticides were screened for control of pine needle scale, with timing of application and coverage receiving special attention. Excellent control was achieved with registered and experimental insecticides sprayed about 1 week after first spring crawlers hatch

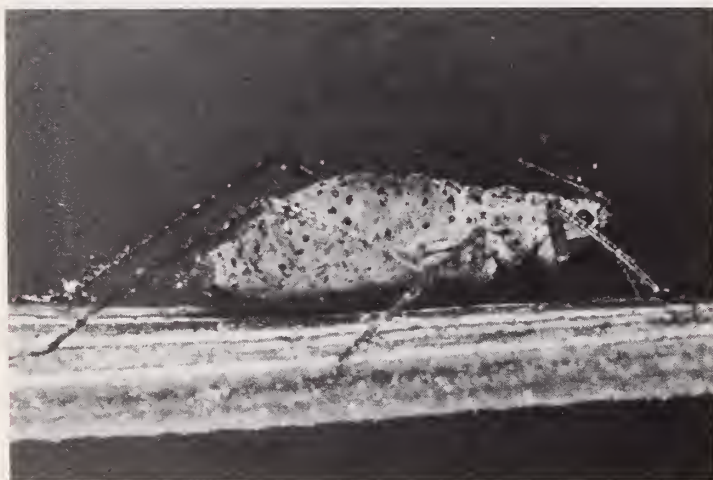


Figure 32. Spotted pine aphid nymph feeding on Scots pine.

(when lilacs are in full bloom). Using plant development (that is, bloom, etc.) to time application of the insecticides will facilitate and improve control programs used by homeowners and commercial growers.

We have described a new mite species, *Trisetacus* sp., which is a serious pest of Scots pine Christmas trees in Scioto and Adams Counties, Ohio. The damage it causes is characterized by proliferation of buds on growth of the current season, with reduced needle length from these buds (fig. 33). When mite populations are high, the resulting rosettes reduce the value of pines grown as Christmas trees.



Figure 33. Characteristic damage caused by *Trisetacus* sp. feeding on Scots pine.

OKLAHOMA STATE UNIVERSITY, 1235

Bionomic, ecology, and control of the Nantucket pine tip moth. R. D. EIKENBARY

A study was made to determine spider populations and their diurnal trends on plantation pines in Oklahoma; to determine relationships among species and locations on trees; and to note predation on species of *Rhyacionia* complex. Fifteen families of spiders were collected from two locations, the most prevalent families, being Anyphaenidae, Theridiidae, Salticidae, Argiopidae, and Oxyopidae. Included in the collection were 52 genera and 55 species. Spiders frequently encountered were *Anyphaena celer*, *Theridion nurarium*, *Mangora gibberosa*, *Cyclosa conica*, *Paraphidippus marginatus*, and *Oxyopes salticus*.

Larvae of the Nantucket pine tip moth were reared successfully on diets containing a wheat germ base. The percentage of pupation on the best wheat germ diet was 28.4, but when mortality during the first stage was excluded, 54 percent pupation was obtained. In two diets, the mean weights of the pupae were close to the weights of field collected pupae.

TEXAS A&M UNIVERSITY, 1525

Electrophysiology of pheromone reception in the southern pine beetle and related bark beetles.

T. L. PAYNE

Previous research has shown that the southern pine beetle and related bark beetles are strongly attracted by aggregation pheromones produced by the bark beetles as well as by host tree odors. The use of these attractive materials offers great potential for manipulation of bark beetle populations and eventual management of these serious pests. Modern electrophysiological techniques currently are being used to measure the response of these insects to the materials that influence their behavior. Electrophysiological responses are recorded from the olfactory receptors of the insect—its antennae. The antennae are covered with numerous tiny hairs which respond to the stimulating materials (fig. 34). This research has shown that bark beetles are responsive to a range of materials. Coupled with behavioral studies, electrophysiological data show that bark beetles are most responsive to beetle-produced pheromones. This research will provide important information on how pheromones and host tree odors can be utilized to manage the southern pine beetle and other bark beetles. The effectiveness of the attractive materials is being evaluated in terms of concentrations required to obtain the desired response, the duration of effectiveness, and the impact of environmental factors on bark beetle response to pheromones and host tree odors.

ADDITIONAL PROJECTS

UNIVERSITY OF ARKANSAS, 656

Significance of IPS bark beetles and associated fungi causing death of pine in Arkansas.

W. C. YEARIAN

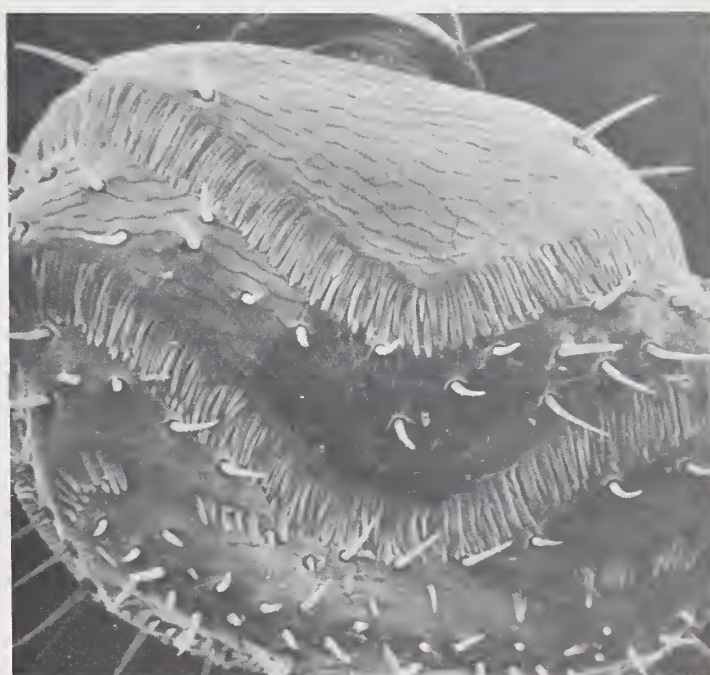
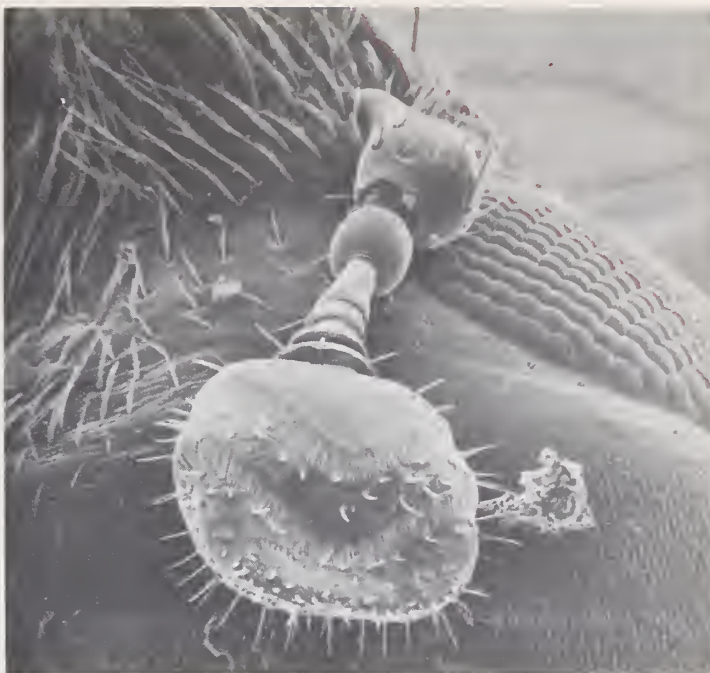


Figure 34. A—Scanning electron micrograph of the club-like antenna of a female southern pine beetle. X-200. B—Scanning electron micrograph of the antennal club of a female southern pine beetle. X-500.

UNIVERSITY OF ARKANSAS, 662

Control of insects affecting seed production of loblolly and shortleaf pines in Arkansas.

W. C. YEARIAN

UNIVERSITY OF GEORGIA, 18

Investigations of insects affecting pine cones and seeds in the Piedmont of Georgia.

R. T. FRANKLIN

UNIVERSITY OF IDAHO, 13

Bionomics and control of cone and seed insects.

J. A. SCHENK

UNIVERSITY OF MAINE, 5007

Biology and natural control of the balsam gall midge.

E. A. OSGOOD

UNIVERSITY OF MARYLAND, 83

Loblolly pine cone insects.

W. E. BICKLEY and F. E. WOOD

UNIVERSITY OF MARYLAND, 101

Survey and evaluation of Maryland forest insects.

A. L. STEINHAUER, F. E. WOOD, and
J. A. DAVIDSON

UNIVERSITY OF MICHIGAN, 14

Population regulation, beetles in aspen.

F. B. KNIGHT

MICHIGAN STATE UNIVERSITY, 942

Investigations on autostability of the arthropod component in single species conifer. J. A. BUTCHER

MICHIGAN TECHNOLOGICAL UNIVERSITY,
2-3119

Biological control of pine bark aphid in forest nurseries.

N. F. SLOAN

MISSISSIPPI STATE UNIVERSITY, 3-205-1029

Study of economic insects attacking certain forest tree seeds and forest seedlings.

W. W. NEEL

UNIVERSITY OF MISSOURI, 149

Insects associated with forest and plantation communities.

W. H. KEARBY

UNIVERSITY OF NEW HAMPSHIRE, 4

Oribatei and Collembola in soils of white pine cover type.

R. M. REEVES

NEW MEXICO STATE UNIVERSITY, 7

Biology and host-finding mechanisms of the ponderosa pine cone beetle in New Mexico.

H. G. KINZER

OREGON STATE UNIVERSITY, F868

Seed and cone insect pests of Douglas-fir.

W. P. NAGEL

PENNSYLVANIA STATE UNIVERSITY, 1750

Development of the eastern spruce gall aphid and its control.

E. A. CAMERON

SOUTH CAROLINA-CLEMSON UNIVERSITY,
905

Biology of pine reproduction weevils in coastal South Carolina.

R. C. FOX and T. M. HILL

TEXAS-STEPHEN F. AUSTIN STATE UNIVERSITY, 11

Flight and attack behavior of IPS bark beetles.

J. E. COSTER

UNIVERSITY OF WASHINGTON, 22

Study of the orientation of bark beetles. (Coleoptera: Scolytidae)

R. I. GARA

UNIVERSITY OF WISCONSIN, 1784

Influence of host-origin antifeedants on sawfly behavior.

D. M. BENJAMIN

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CONTROL OF DISEASES, PARASITES, AND NEMATODES AFFECTING FORESTS

Research Problem Area 202

Forest disease research is essential to protect and enhance the social and economic value of trees in forests and farm woodlots. Diseases reduce the utility of trees for wildlife habitat and timber production. They kill trees, discolor foliage, retard growth, and cause decay leading to breakage and windfall. Prolonged droughts, wet periods, and changing climatic conditions accentuate tree disease problems.

ALABAMA—AUBURN UNIVERSITY, 911

Ingression of Hypoxylon atropunctatum and

Hypoxylon punctulatum into southern oaks.

T. C. DAVIS

Several *Hypoxylon* species were found to invade and persist in the sapwood of necrotic limbs of southern oaks until the sapwood is completely degraded. This phenomenon occurred frequently in lower limbs that became necrotic from physiological suppression, and is important with respect to *H. atropunctatum* since it is parasitic to weakened trees. Approximately 50 percent of such limbs above 4 inches in diameter harbored either *H. atropunctatum*, *H. mediterraneum*, *H. punctulatum*, or other *Hypoxylon*-like fungi. The incidence decreased with decreasing limb diameter. *H. atropunctatum* is the most common, followed by *H. mediterraneum* and *H. punctulatum*. Results of inoculation experiments indicate that neither *H. punctulatum* nor *H. mediterraneum* is parasitic to weakened trees, although they do invade dying and dead stems very rapidly. *H. atropunctatum* was associated in the death of 71 percent of necrotic ancillary stems of twin-stemmed oaks. Ingression commonly occurs slightly above the crotch. Root invasion does not occur. Insect vectors in the dissemination and spread of *Hypoxylon* species appear unlikely, since these fungi usually invade prior to insect activity.

UNIVERSITY OF CALIFORNIA, 2383

Studies on epidemiology and control of Fomes annosus root rot.

F. W. COBB

Previous studies on the ecology of *Fomes annosus* in stumps have been concluded. Results show that numerous microorganisms and insects occur in stumps with *F. annosus* and that some interact with this root pathogen. However, none have yielded promising results in relation to biological control of stump surface infection. Moisture on the stump surface appears to be a factor limiting infection of stumps, but moisture within the stump remains adequate for colonization over an extended time period. Studies on the movement of *F. annosus* through soil and the effects of soil factors are continuing. Inoculations of ponderosa pine trees with *Verticicladiella wagnerii* were made during 1971 to determine the effects of soil, host age, host vigor, and season of inoculation on infection. Preliminary data indicate little or no infection of larger trees

inoculated during the summer months. Analysis of soils from sites of infection may show a positive relationship between disease severity and poor soil drainage and higher quantities of soil manganese. Foliar analysis shows small but significant differences in the mineral content of foliage from diseased versus healthy trees. Exploratory studies are being conducted in the laboratory to determine the effects of soil factors on survival of and infection by *V. wagnerii* in the soil.

LOUISIANA TECH UNIVERSITY, 52

Morphology and cytology of fusiform rust and eastern gall rust in five pine species artificially inoculated with known isolates of each rust species, and the associated anatomical reaction of the hosts.

F. F. JEWELL

Forest pathologists generally consider southern fusiform rust the most important pine disease in the South. This disease attacks and causes extensive mortality in three of the four major pine species in the South. The disease is prevalent in natural stands, plantations, and pine nurseries. The planting of infected nursery stock invariably leads to seedling mortality or deformity.

The primary purpose of this project is the morphological study of two pine-rust fungi: Southern fusiform rust and eastern gall rust. A thorough study of these fungi possibly will answer needs of basic research in either revealing significant differences in the two fungi or showing them to be the same species. These two possibilities have been scientific arguments for several years.

In addition, study of particular samples from artificially inoculated pines has revealed indications of anatomical resistance to fusiform and eastern gall rust. These findings are actively being pursued. If a definite mechanism of resistance is found and confirmed, the forest geneticist will have a tool with which to improve the forests of the South. Such a tool would allow breeders to produce an improved pine tree for the forests which would be able to resist the attack of a very destructive disease, thus remaining on the land for longer periods of time to allow more public benefit and economic gain.

LOUISIANA TECH UNIVERSITY, 51

*Cultivation of *Cronartium fusiforme* on selective artificial media.*

F. F. JEWELL, J. WHITE, and S. ALEXANDER

Tissue culture research to grow *Cronartium fusiforme* on artificial media has been continued using more sophisticated techniques developed from previous findings. The Forest Disease Laboratory, Southern Forest Experiment Station, USDA, Gulfport, Miss., cooperated in the project by supplying young rust-infected tissue.

Cultures of callus tissue have been subjected to artificial rust inoculation at the Gulfport lab. These cultures are still growing and have been subcultured for continued observation. Where necessary, future subculturing will be done under State appropriations and under a Federal grant other than McIntire-Stennis.

LOUISIANA TECH UNIVERSITY, 22

Effects of controlled burning on soil microorganism populations in Robert's plots, Urania, La.

E. R. ANDRULOT, J. MURAD, and S. BAMFORTH

This project has demonstrated new species of nematodes which were recovered from Robert's plots. It has shown new record habitats for some species and genera of nematodes. Many varieties of parasitic nematodes have been found in the rhizospheres of the pines. Studies of the parasitic species of nematodes to find the effects that parasites have on the productivity and economic yield of the forest pine are being continued. They should reveal whether surface burning is a control measure against parasitic nematodes infecting pines.

LOUISIANA TECH UNIVERSITY, 5

Pine-oak gall rusts in the South in relation to conifers and angiosperms.

F. F. JEWELL

Data on this project, which was terminated 30 June 1971, were compiled and analyzed from observations on the haploid mycelium of *Cronartium fusiforme* in slash pine and *C. quercuum* in jack and Virginia pine. Data on *C. fusiforme* in loblolly pine were also included. Evaluation was done on a quantitative basis and by computer analysis. Since the data did not give

definitive results, a more comprehensive computer study has been conducted.

UNIVERSITY OF MASSACHUSETTS, 1

Etiology of maple tree decline in Massachusetts.

W. M. BANFIELD

Sugar maple decline is characterized by premature coloration of leaves, progressive marginal scorch of leaves, premature defoliation, dieback, and death. It occurs in environments of high stress for water and on trees subjected to extensive root injury. The roadside environment is the most common site. Other common sites are southern and western exposures, shallow soils on rocky ledge, pastured swales, and timber harvest areas where trees are suddenly exposed by removal of surrounding trees. The disease can be induced readily by prolonged water withholding and be cured by weekly watering over a 2-year period. Its ecological parameters are full exposure to sun and wind, lack of ground shade, low relative humidity, high evapotranspiration, high soil temperature, low soil moisture, and high-soil bulk density (compaction). Roots of declining trees in compacted soils are moribund; those beside highways are atrophied because of pavement overlays or ground fills, or are severely injured by excavation or plowing if located beside fields. Tension for water in declining trees may exceed 1,600 psi; in healthy trees, as in salted trees, it rarely exceeds 400 psi. Scorched leaves of roadside trees commonly have the highest salt concentration and habitually are on sites of maximal exposure. Roadside forest trees mostly are void of decline. Maximal salt found beside highways did not exceed 1 ton per acre. Summer application of 1 ton per acre induces trivial symptoms. Trees watered daily with a 2-mgm salt solution developed severe decline when fully exposed, but shaded trees shielded from wind produced no such symptoms.

UNIVERSITY OF MICHIGAN, 15

Isolation of microorganisms from preservative treated wood and effect on wood preservatives.

H. L. MORTON

To determine if there was a succession of microorganisms in wood treated with 98.5 percent creosote (C), 15 percent pentachlorophenol (P) in No. 2 fuel oil, or 4.5 percent tanalith (T) in water, stakes were placed in the soil at Ann Arbor (AA),

Pellston (Pel), and Iron River (IR). After various exposure periods, five randomly selected stakes per treatment were removed from each plot. Isolations were made from two sides of each stake by aseptically removing 1/16-inch-thick facings from the underground portion and dissecting eight chips from the exposed surfaces at a point 2 inches below the soil. Four chips were placed on a preservative medium and four on PDA. No microorganisms were isolated from the initial controls. After 8 months exposure, all stakes remained sterile at Pel, while bacteria were found in the C and T treatments at AA and in all treatments at IR. No fungi were found. After 1 year, bacteria were isolated from all treatments at all field locations, except at Pel where bacteria had not colonized the P and T treatments. Fungi were found at all locations, but in the C and T treatments only. *Trichocladium*, *Trichoderma*, and *Phialophora* sp. were consistently isolated from T while *Hormodendrum*, *Torula*, and *Rhinotrichum* were isolated from C. These data show the importance of geographic location and preservative on microorganism succession and support other studies in which bacteria preceded fungal colonization of woody substrates.

OREGON STATE UNIVERSITY, 819

Phytophthora root rot.

L. F. ROTH

Efforts to stay extinction of the beautiful and valuable native Port Orford-Cedar continue with adjustments to realities arising from previous research. Since rooted cuttings from trees selected for field resistance die in screening tests without evidencing significant genetic resistance to *Phytophthora* root rot, we are looking to other species for resistance and to other paths for survival. Japanese tree breeders who want to adapt oriental species of *Chamaecyparis* to higher elevations are providing seed of oriental species and later, we hope, seed of hybrids with *C. lawsoniana* for testing for root rot resistance. We sent them pollen from higher elevation cedars in exchange. Methods for mass inoculation and screening have been developed by adopting technology of seedling production in plastic bullets. Fifty individual seedlings are simultaneously treated by brief partial immersion of a rack of perforated bullets in the inoculum slurry. A second approach to saving the cedars involves limiting damage in selected forest areas by planning and management based on

knowledge of fungal spread and survival and on land-use expectations. The fungus spreads by human activities that move soil, by flow of surface water, and by livestock. A search for more subtle forms of movement and for limitations on movement and survival, as these relate to infection probabilities, has been undertaken. As an initial step, we have taken color aerial photos to locate (1) stands appropriate for protection, (2) infection sources, and (3) sites appropriate for study.

UNIVERSITY OF TENNESSEE, 15

Biological control of soil-borne fungi. F. W. WOODS

Soil-borne pathogens exact a heavy toll of trees each year, killing seedlings as well as trees in more mature stages of growth. The theory has been advanced that one mechanism through which ectotrophic mycorrhizae may reduce such losses is by producing antibiotics that inhibit disease-causing fungi.

During the past year, four species of mycorrhizal fungi common in east Tennessee were assayed for antagonism toward 11 pathogens. Of those tested, three have shown moderate to strong antagonism to certain pathogenic fungi. *Cennococum graniforme* is strongly antagonistic to *Fomes annosus* and *Pythium irregulare*, and shows moderately strong antagonism to five others. *Amanita rubescens* is strongly antagonistic to *Pythium irregulare* and moderately so to three others. *Laccaria laccata* has shown moderately strong antagonism toward five pathogens.

All the tests reported here were made under laboratory conditions. Tests made under field conditions, where growth rates of the various fungi may differ, will be necessary for confirmation of results.

UNIVERSITY OF WASHINGTON, 8

Fomes annosus under stand management in Northwest. C. H. DRIVER

Research results show: (1) *Fomes annosus* was prevalent and induced mortality in planted western hemlock and Douglas-fir. How such initial infection occurred still is to be determined. (2) Dry borax applied immediately after tree-felling still appears to be the best chemical control of stump infection under a wide range of Northwest forest site and operational

conditions. (3) Western hemlock forest 30-60 years of age which exhibit over 40 percent stem infection by *Fomes annosus* at the time of the first commercial cutting should be harvest cut rather than continue management of the stand. (4) Additional research is needed on methods for managing stands younger than 30 years of age which exhibit *Fomes annosus* butt-rot previous to the first cutting operation.

UNIVERSITY OF WISCONSIN, 1264

Oak wilt, its development, spread, and control.

J. E. KUNTZ

Sucrose, glucose, fructose, more than 20 amino acids, zinc, iron, potassium, and sodium have been identified in healthy sap of red oak. Concentrations of soluble carbohydrates, mainly sucrose, increased in xylem sap of inoculated trees as disease symptoms progressed.

Pathways of tryptophan catabolism by *Ceratocytis fagacearum* are being defined to help elucidate the possible significance of fungal-produced auxins in disease development. The pathogen synthesizes indole acetic acid, tryptophol and indole-3-aldehyde from L-tryptophan, and also catabolizes tryptophan by the aromatic pathway as evidenced by the excretion and accumulation of anthranilic and 3-hydroxy anthranilic acids and by the oxidation of kynurenine. The indole synthetic pathway appears inducible while aromatic degradation appears constitutive. The two separate pathways result in competition for available tryptophan, with the aromatic pathway favored and the indole pathway suppressed unless an exogenous carbon source is supplied. Washed mycelium and mycelium-free conidial suspensions can degrade tryptophan by both pathways.

More than 75 percent of 2-month-old red oak seedlings inoculated by root-cut and stem-injection methods wilted in several experiments, and the pathogen could be recovered readily from the wilted tissues. Results, however, varied among experiments, and environmental factors seem to be important in the rate of symptom expression.

Regulated dosages of Benzylaminopurine-riboside (BAP-R), a soluble cytokinin, reduced symptom expression. *C. fagacearum* could not be recovered from oaks injected with BAP-R and then inoculated,

but was recovered from 85 percent of the controls. Light and electron microscopy studies showed a suppression of tyloses formation in trees treated with BAP-R, possibly due to overgrowth of vessel-parenchyma pit membranes. A gradient of tylosis formation was evident; tyloses were seldom observed near the BAP-R injection site while, at some distances, tyloses were abundant (fig. 35).

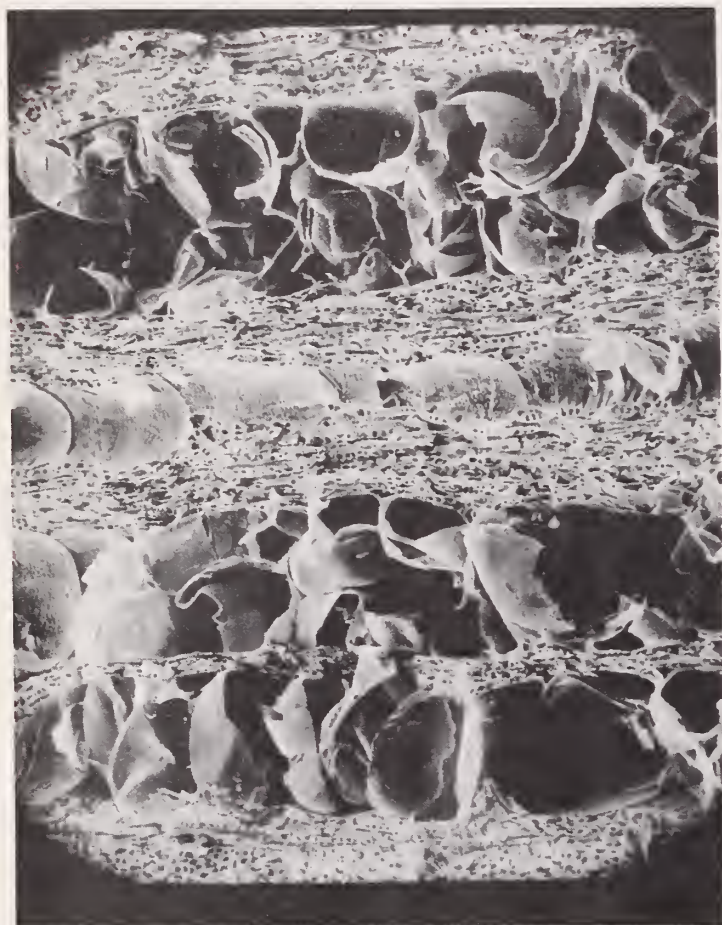


Figure 35. Abundant tyloses formed in xylem vessels of a red oak inoculated with *C. fagacearum* but not treated with cytokinin. Micrograph taken on the scanning electron microscope of the Forest Products Laboratory. X-80.

ADDITIONAL PROJECTS

UNIVERSITY OF ARKANSAS, 663

Organelles of fungi causing forest-tree diseases.

F. H. TAINTER

UNIVERSITY OF ARKANSAS, 741

Plant viruses in forested areas.

J. P. FULTON, J. M. McGUIRE, and
H. A. SCOTT

UNIVERSITY OF CALIFORNIA, 2348

Microbiology and pathology of wetwood in California firs.

W. W. WILCOX

UNIVERSITY OF HAWAII, 721-F

Natural microbial antagonism in forest soil of Hawaii.

W. H. KO

UNIVERSITY OF IDAHO, 11

Decays of inland-northern timber trees.

A. D. PARTRIDGE

UNIVERSITY OF MARYLAND, J-101

Forest tree seedlings and soil fungi relationships.

W. L. KLARMAN

MICHIGAN STATE UNIVERSITY, 1049

Decay and termite resistance of Michigan woods and derived products.

E. A. BEHR

UNIVERSITY OF MICHIGAN, 19

Influence of air pollutants on infectious tree diseases.

H. L. MORTON

MICHIGAN TECH UNIVERSITY, 3028

Decay and discoloration associated with sugar maple borer injury.

G. A. HESTERBERG

UNIVERSITY OF MINNESOTA, 19-79

Productivity of forest ecosystems.

E. V. BAKUZIS

UNIVERSITY OF MINNESOTA, 22-018

Dwarf mistletoe infection, spread, detection, and control.

D. W. FRENCH, M. P. MAYER, and
F. D. IRVING

NORTH CAROLINA STATE UNIVERSITY, 4012

Ecology of forest tree diseases and wood deterioration.

L. F. GRAND and E. B. COWLING

OHIO AGRICULTURAL RESEARCH AND
DEVELOPMENT CENTER, 8

Disease problems in plantation trees in Ohio.

C. LEBEN, H. R. KRIEBEL, and B. THIEGLES

PENNSYLVANIA STATE UNIVERSITY, 1702

Epidemiology of forest tree diseases.

F. A. WOOD

PENNSYLVANIA STATE UNIVERSITY, 1825

An annual canker of maple.

W. W. WARD, F. A. WOOD, and T. W. BOWERSOX

UNIVERSITY OF TENNESSEE, 7
Blight resistance in American chestnut. E. THOR

TEXAS A&M UNIVERSITY, 1526
Etiology and control of live oak decline.
E. P. VAN ARSDEL

WASHINGTON STATE UNIVERSITY, 1770
Development and pathogenicity of hypoxylon fuscum in Northwest species of alder. J. D. ROGERS

UNIVERSITY OF WISCONSIN, 1434
Etiology epidemiology and control of forest plantation root diseases. R. F. PATTON

UNIVERSITY OF WYOMING, 928
Diseases of aspen in Wyoming. W. D. ROSS

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Chapter 5

FOREST MENSURATION

Forest mensuration has been described as a science dealing with the measurement of volume, growth, and development of individual trees and stands, and the determination of various products obtainable from them. Assessment of site quality, age determination, stand density, survey, and mapping are included in the discussion of forest mensuration. Tests of new approaches to sampling problems are also described in this chapter.

APPRAISAL OF FOREST AND RANGE RESOURCES

Research Problem Area 110

Periodic appraisals of forest and range resources of the Nation are essential to determine the adequacy of public conservation policies and programs and to guide the development of private forest and range enterprises.

The timber resources of the Nation, including some 500 million acres of commercial forest land, vary greatly in productivity and availability for industrial use. They show widely divergent trends in growth, depletion, and quality. The increasing use of resource data to evaluate future needs of Federal and State forestry programs and to provide guidance for the continuing expansion of wood-using industries in various regions makes it imperative that appraisals of timber resources be intensified and kept up to date.

The range resources of the Nation vary widely in productivity, condition, and potential importance for sustaining livestock and wildlife. There is growing need for a comprehensive appraisal of range conditions and opportunities for improving capacity and use to meet future demands for livestock forage, water yield, and of wildlife habitat.

CALIFORNIA—HUMBOLDT STATE COLLEGE, 17
*Vegetation habitat types of the Salmon Mountains,
northwest California.*

D. A. THORNBURGH and J. D. SAWYER

The Klamath Mountain Region of northwest California has been called the "center of western American forests" because the species of the Pacific Northwest, Northern Rocky Mountains, and California meet in the region. It is considered to have the largest natural concentration of conifers anywhere in the world. The Russian Peak area of the Salmon Mountain Range in the eastern end of the Klamath was chosen for initial studies because it has a very diverse mixture of Pacific Northwest and California mountain conifer species.

Vegetation habitat types were developed from a total of 328 sample plots taken in the Salmon Mountain Range. These vegetation habitat types are being used to help explain the distribution of the relict conifer stands that occur in this region. Productivity values are being developed for most species on each habitat type. An identification key will be developed to enable land managers to inventory wildlands by these types. This will enhance coordinated decisionmaking of wildland managers in the area.

CALIFORNIA—HUMBOLDT STATE UNIVERSITY, 25

Total bole cubic foot volume table and bark volume relationship in old growth redwood. **D. L. ADAMS**

Procurement of three computer programs, review for suitability of desired data manipulative routines, and modification for the available cooperating system is progressing well, and the literature review has been completed. One trip of 600 miles (includes return) was required to collect the donated data. Subsequent data were collected in the field to boost the data base and fill in any data gaps. Previously adapted statistical packages were reviewed for their potential in determining regression validity. A computer program was written to calculate the cubic contents of redwood log components.

COLORADO STATE UNIVERSITY, 323

Evaluation of timber-supply forecasting methods—stochastic approaches. **W. E. FRAYER**

A stochastic process was developed for predicting forest stand composition over time. The method is similar to procedures used by the USDA Forest Service in updating timber-resource statistics for national appraisals, but also allows calculation of variances due to the model.

The basic model includes predictions of four values and associated variances over time; that is, the expected number of (1) live stems, (2) unharvested mortality, (3) harvested growing stock, and (4) harvested mortality. Predictions are made for each diameter class, and estimates of volume including cumulative cut and mortality are available.

As a test, the model—including 32 derived equations—was applied to data supplied by the Forest Survey Project, Northeastern Forest Experiment Station, USDA Forest Service. The data consisted of stand tables for softwoods and hardwoods from the 1959 and 1971 inventories of the State of Maine. When applied to the 1959 data and projected for 12 years, the model yielded predictions in close agreement with the actual 1971 data. All 1971 figures supplied for numbers of live stems were within one standard deviation of the estimates yielded by projection, and differences were less than 5 percent in each diameter class.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION, 414

Multivariate analysis of hardwood plot data.

P. E. WAGGONER and G. R. STEPHENS

Enumerations of the trees in unmanaged hardwood forests in 1927, 1937, 1957, and 1967, and in other hardwood forests in 1959 and 1970 have permitted extraordinarily firm appraisals of the natural changes in the forests of the Northeast during an era of suburbanization and defoliation. Transition probabilities determined for successive intervals were relatively steady and provided a means of summarizing the significant changes and of anticipating the steady state toward which the forest is tending. Where there are few conifers, the tendency is toward a future forest with little oak and much maple and birch. Where the forests now contain considerable conifers, however, the tendency is toward a future forest dominated by conifers. Repeated defoliation by insects increased mortality and caused some large trees to die, but over a decade the increase in mortality no more than doubled.

UNIVERSITY OF GEORGIA, 21

Prediction of growth and yield of loblolly and slash pine plantations. **J. L. CLUTTER**

Project activities during the past year included: (1) Completion of a dissertation draft presenting new plantation growth and yield models developed from data obtained in *Pinus radiata* plantations in New Zealand; and (2) initiation of a cooperative study with the USDA Forest Service to evaluate the effects of thinning in slash pine plantations.

SOUTHERN ILLINOIS UNIVERSITY, 04—B—067

Dendrochronology of shortleaf pine.

W. C. ASHBY

Tree-ring samples (increment cores) from living trees at 61 different forest sites were analyzed by using skeleton plots and several computer routines to determine the effect of climatic influences on the growth of black oak, white oak, and shortleaf pine. All cores were cross-dated within each species and between species by skeleton plots, and a specific calendar year was assigned to each annual ring. Black oak was easier to cross-date than white oak or pine. Computer-calculated negative mean sensitivity values

verified cross-dating by skeleton plots. Comparisons of site chronologies derived from both the skeleton plots and the index routine for each species showed that a number of narrow rings consistently occurred in certain years throughout the Central Mississippi Valley. Within any species, the degree of similarity in narrow rings decreased as the distance between sites increased. Major changes in soil types also influenced the number of narrow rings; thus, ecological differences may occur within the same species as well as between species. Information about the past history of the stand and its present ecology may be obtained from the increment cores and the ring-width listing routine. Bivariate distribution tables indicated that, for each species, annual ring widths correlated highest with certain periods of precipitation. Analyses of variance permitted the evaluation of relative similarities and differences of tree-growth response and indicated past stand disturbances as well as the effects of climatic and edaphic influences. Pine has greater tree-to-tree variability on clay soils than on cherty soils. Oaks have more tree-to-tree variability on cherty soils. Black oak responds primarily to climate.

NORTH CAROLINA STATE UNIVERSITY, 4014

Estimation of parameters in non linear models of tree growth. **W. L. HAFLEY**

In an attempt to provide an evaluation of a particular non linear estimation technique available through the SHARE organization, a study of its performance as it relates to one family of growth curves was undertaken. The particular family of growth curves chosen was of the form $Y = B_1(1 - e^{B_2 X^{B_3}})^{B_4}$. Error surfaces were generated in the parameter space by determining the sum of squares at grid points whose coordinates were specified values of the four parameters. The goals were to determine how one might expect the surface associated with this family to appear, and to evaluate the potential for local minima solutions.

Once the surfaces were mapped and their characteristics known, the nonlinear search procedure was applied to the data to determine if the procedure would, in fact, obtain the coordinates of the "best" combination of parameters or be caught in some local minimum. The results to date indicate that the surface does indeed have local minima and that the

choice of an initial parameter coordinate for beginning the search is crucial to reaching a solution that is a global, or true minimum.

MICHIGAN TECHNOLOGICAL UNIVERSITY, 2-3012

Development of a standardized program for automatic data processing of forest measurement records.

W. METEER

The Michigan Technological University Standard CFI program was used for computation of two industrial CFI cases and for computation of data from several Ford Forestry Center research projects. Advanced procedures were developed for data file maintenance and updating.

UNIVERSITY OF MICHIGAN, 17

Sampling of tree characteristics and the application of sequential analysis to forest sampling.

G. W. FOWLER

Established nine field plots in Michigan's Upper Peninsula, and Barr and Stroud measurements were taken on all trees in each plot. A plot was established in each of the following types: (1) old growth white pine, (2) mature jack pine, (3) small sawtimber red pine, (4) small sawtimber white pine, (5) managed northern hardwood, (6) mechanically thinned jack pine pole stand, (7) northern hardwood pole stand, (8) red pine pole stand, and (9) aspen pole stand. Present plans are to remeasure the trees on these plots in 3 years. Each plot will represent a small forest stand where various methods of sampling for growth can be compared.

Developed a Monte Carlo technique using Bitterlich point sampling for estimating the basal area and board-foot volume per acre of a rectangular forest stand. The relationship between the variance of the estimate, Basal Area Factor, and number of sample points was investigated for various forest sizes. Estimates with and without correction for edge effect were compared.

Developed a one-sided truncated sequential t-test, based on Monte Carlo techniques. A set of such tests has been developed for $\alpha = 0.05$ and various truncation points and probability boundary patterns. The OC and ASN functions of these tests have been

approximated using Monte Carlo techniques. Investigated further the errors inherent in Wald's Sequential Probability Ratio Tests. Compared truncated test with Barnard's open one-sided sequential t-test.

OREGON STATE UNIVERSITY, 843

Prediction of growth and yield of young-growth Douglas-fir stands. **D. P. PAINE**

The following were accomplished during the study. (1) The relationship of crown diameters over stem diameter for open-growth Douglas-fir trees was established as a second degree polynomial. (2) Two CCF equations were developed—one uses number of trees/acre by dbh class; the other uses basal area/acre by dbh class. (3) The latter equation was combined with the variable plot equation to give CCF values directly from variable plot data. (4) Appropriate tables were developed which makes the calculation of CCF (either equation) a simple matter. (5) Based on Douglas-fir yield tables, CCF appears to be independent of age and site. (6) Relationships between CCF, BA, relative BA, and SDI were established. (7) CCF was found to be a slightly better predictor of cubic-foot growth than any of the other three measures of density. (8) Coefficients of spatial distribution could not be accurately determined from aerial photographs.

TEXAS—STEPHEN F. AUSTIN STATE UNIVERSITY, 7

Estimating volume of southern forest species by the tariff method. **H. V. WIAINT, JR.**

The tariff system of volume determinations was compared with conventional methods in nine sawtimber and 12 pulpwood size southern pine stands in Texas, Arkansas, and Louisiana. The tariff system generally compared rather poorly with conventional methods.

UNIVERSITY OF VERMONT, 4

Volume equations for major forest trees.

C. C. MYERS

Field tests incorporating xylometer techniques were conducted at the University of Vermont research forest on cubic-foot volume equations used in Vermont. In these tests, the species-group volume equations used by the USDA Forest Service for the

Vermont forest survey gave the most accurate results. The Geuorkiantz composite volume equation used in the Vermont State forest inventory ranked second. Locally developed cubic-foot volume equations gave the least accurate results of the equations tested. From these tests, it appears that the forest survey and Geuorkiantz equations are satisfactory, and there is little justification for continuing the expensive development of cubic-foot volume equations for Vermont.

ADDITIONAL PROJECTS

NORTHERN ARIZONA UNIVERSITY, 3

Past vegetation and climates of ponderosa pine zone in northern Arizona. **D. W. BERRY**

UNIVERSITY OF ARIZONA, 2016—4168—022

Development of volume tables for ponderosa pine from aerial photos. **G. S. LEHMAN**

UNIVERSITY OF CALIFORNIA, 2350

Methods of estimating long-range timber supply.

H. J. VAUX

UNIVERSITY OF CALIFORNIA, 2520

Mathematical simulation of forest stands.

L. C. WENSEL

COLORADO STATE UNIVERSITY, 328

A model for multiple-use resource decisions in the ponderosa pine ecosystem. **H. W. STEINHOFF**

COLORADO STATE UNIVERSITY, 324

Classification of complex resource systems.

C. D. BONHAM

UNIVERSITY OF IDAHO, 1

Site relationships and productivity of foothill woodland-shrub grazing lands in Idaho.

E. W. TISDALE

INDIANA—PURDUE UNIVERSITY, 1586

Design of forestry data processing system.

C. C. MYERS

UNIVERSITY OF MISSOURI, 167

Determination of optimum photo scale and type of film for Missouri forest conditions. **A. J. NASH**

UNIVERSITY OF MONTANA, 3001
Ecosystem study of the Elk Creek drainage in western Montana. L. K. FORCIER and R. F. WAMBACH

NEW YORK—STATE COLLEGE OF FORESTRY
AT SYRACUSE UNIVERSITY, 110—0—8
Sampling systems for inventory of forest resources.
C. A. BICKFORD

OREGON STATE UNIVERSITY, 883
Regeneration surveys using aerial photography and multistage, pps sampling techniques.
D. P. PAINE and J. F. BELL

SOUTH DAKOTA STATE UNIVERSITY, 556
Visual documentation of successional changes of the Black Hills pine forest. D. R. PROGULSKE

TEXAS A&M UNIVERSITY, 1761
Growth and yield of pine plantations in east Texas.
D. M. MOEHRING and R. G. MERRIFIELD

TEXAS—STEPHEN F. AUSTIN STATE UNIVERSITY, 1
Cubic-foot yield of old-field unthinned loblolly pine plantations. J. D. LENHART

UTAH STATE UNIVERSITY, 757
Conifer distribution in the Great Basin and adjacent mountains. R. M. LANNER

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BIOLOGY, CULTURE, AND MANAGEMENT OF FORESTS AND TIMBER-RELATED CROPS

Research Problem Area 111c

Culture and management are directed at producing adequate supplies at reasonable cost, by methods that harmonize with other forest uses. For the 40 important commercial timber types in the United States, it is necessary to develop techniques for intensive culture on the most accessible and productive sites; and methods for combining timber culture with other uses on the remaining sites. The major job is to find out how to convert wild forests to managed forests of better species, higher quality,

and faster growth in the shortest time and at least cost. Each type, including Christmas trees, has distinctive silvicultural characteristics. Research devises improved cultural techniques for the more than 130 commercial timber species, and better methods for forecasting growth and quality changes in relation to management practices, thus providing the basis for selection of economic alternatives.

CALIFORNIA—HUMBOLDT STATE COLLEGE, 16
A growing stock-thinning test of Douglas-fir and associated species.

E. W. PIERSON and D. A. THORNBURGH

The levels-of-growing stock plots have been thinned and initial tree measurements have been completed: total height, diameter at breast height, and crown dimensions in four directions. Periodic measurements will be made to determine differences in tree and stand growth as influenced by the different levels-of-growing stock.

MICHIGAN TECH UNIVERSITY, 2-3117
Forecasting value growth on northern hardwood forest land.

W. R. WYND

This study proposed a system of forecasting value growth on northern hardwood lands. The valuation procedure is based on the relationships among (1) stand value and tree grade and value mix, (2) individual tree values and the value of their respective log grade mix, and (3) log values and their recoverable product potential.

A series of nine multiple linear regression equations were computed to express the value of sugar maple, yellow birch, and other hardwoods. These equations may be used to estimate individual tree value on the basis of five variables and one constant. The first two variables are species and tree grade; these are used to select the proper Tree Quality Index (TQI) equation. The second two variables, DBH and merchantable height, are used within the proper equation to estimate weighted TQI. Finally, tree value is estimated by multiplying the TQI value by tree soundness and the current price of No. 1C lumber for that particular species. The resultant value is the estimated value of the 4/4-inch factory grade lumber recoverable from the tree.

This system of stand evaluation is realistic, easily adapted to normal inventory techniques, and provides

useful information for future planning and decisionmaking.

LOUISIANA TECH UNIVERSITY, 1

Yields from Chapman loblolly pine thinning plots.

L. P. BLACKWELL and E. R. ANDRULOT

Additional information has been obtained on expected growth and yield of loblolly pine. Various thinning regimes have been tested for both pulpwood and sawtimber rotations. Economic analyses were made of the value of thinnings and the cost and returns for carrying stands to various rotation lengths. Remeasurements on plots which have been continuous since 1931 are being conducted by the Louisiana Tech School of Forestry under State appropriations.

ADDITIONAL PROJECTS

NORTHERN ARIZONA UNIVERSITY, 1

Ponderosa pine stand density measures. **C. O. MINOR**

CALIFORNIA—HUMBOLDT STATE COLLEGE, 21

Effect of nitrogenous fertilizer on the growth of Douglas-fir and redwood.

E. W. PIERSON and D. A. THORNBURGH

MICHIGAN TECHNOLOGICAL UNIVERSITY, 2—3311

Tariff tables for aspen in the western upper peninsula of Michigan.

V. W. JOHNSON

UNIVERSITY OF MINNESOTA, 19—045

Study of forest stand dynamics by means of stochastic simulation models.

D. J. GERRARD and E. I. SUCOFF

NEW YORK—STATE COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 111—5—5

Dynamic models on growth of stands for determining allowable cut.

T. CUNIA

OKLAHOMA STATE UNIVERSITY, 1476

Simplified forest sampling based upon estimated stem distribution parameters.

N. WALKER

PENNSYLVANIA STATE UNIVERSITY, 1805

Stochastic models for the simulation of even-aged forest stand systems.

P. E. DRESS

SOUTH CAROLINA—CLEMSON UNIVERSITY, 4
Utilizing aerial photographs to promote better forest management.
W. A. SHAIN

TEXAS—STEPHEN F. AUSTIN STATE UNIVERSITY, 6

Weight and volume for individual trees in loblolly pine plantations.

J. D. LENHART and S. I. SOMBERG

UTAH STATE UNIVERSITY, 806

Sampling requirements for biomass and productivity measurements in spruce and fir.

T. W. DANIEL

WASHINGTON STATE UNIVERSITY, 2002

Growth and yield of even-aged forest stands.

L. V. PIENAAR

WEST VIRGINIA UNIVERSITY, 5

Growth and Yield of hardwoods.

D. L. KULOW

UNIVERSITY OF WISCONSIN, 1675

Quantification and simulation of forest growth.

A. R. EK

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REMOTE SENSING

Research Problem Area 113

Programs in agriculture and in agricultural development are heavily dependent on having timely information for decision making. Opportunities for increasing and sustaining the productivity of natural resources and for facilitating product flows in agriculture are dependent on accurate, comprehensive, and timely information on resource use, availability, productivity potential, and other characteristics. The paucity of such information is a major obstacle in the economic development of undeveloped regions of the world and a significant obstacle to the formulation of important policies and programs in the more fully developed regions.

Generally, such information on natural resources has been obtained from ground surveys. These surveys are costly and, in the more remote and inaccessible regions of the world, are difficult, if not impossible, to make.

NORTHERN ARIZONA UNIVERSITY, NAU-07

Aerial surveys of land and timber resources.

T. E. AVERY

Work continues on the proposed airphoto atlas. Additional listings of USDA photographs are being compiled; specific contact prints will be selected early in 1972 at the ASCS Aerial Photography Laboratory in Salt Lake City. These photos, along with prints previously chosen of eastern United States, will

comprise a large segment of the airphoto/map atlas.

ADDITIONAL PROJECTS

ALABAMA-AUBURN UNIVERSITY, 909

Standardized forest condition classes for aerial forest inventory.

E. W. JOHNSON

UNIVERSITY OF CALIFORNIA, 2180

Multiband spectral reconnaissance for forestry.

R. N. COLWELL

UNIVERSITY OF MASSACHUSETTS, 13

Remote-sensing 20 years of change in the human environment in Massachusetts, 1951-1971.

W. P. MacCONNELL

NEW YORK-CORNELL UNIVERSITY, 906

Resources inventory and analysis for environmental planning.

L. S. HAMILTON and E. E. HARDY

PUBLICATIONS

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The role of resource inventories and landscape ecology in the highway route selection process. Cornell University, Office of Regional Resources and Development, 198 pp. 1971.

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Chapter 6

FOREST MANAGEMENT

Forest management is the application of business methods and technical forestry principles to the operation of forest property. Research in forest management may deal with several important types of considerations, including theoretical aspects of yield and growing stock; annual or periodic yield and yield regulation; business aspects of forestry; calculations of costs and profits and forest valuation; and accounting and other financial aspects.

ECONOMICS OF TIMBER PRODUCTION

Research Problem Area 303

Timber production efficiency research investigates how income can be increased through effective use of labor and capital. Such information is generally lacking for the wide variety of forestry investments possible in different areas. Returns of expenditures for planting, stand improvement, and other timber growing activities vary widely throughout the Nation and depend on many cost factors, including the quantity and quality of timber yields and local market conditions. Identifying the most profitable opportunities for management of public forestry programs and for private investments on forest lands is basic to efficient allocation of the funds available for timber growing.

UNIVERSITY OF GEORGIA, 19

Cash flow and forest management policy as related to income and taxes.
J. L. CLUTTER

Research was initiated to explore the suitability of various forest management decision criteria under imperfect capital market conditions. Consideration is given to defining the circumstances in which the present net worth and return on investment criteria

are optimal and to developing alternative criteria appropriate to other sets of circumstances.

NORTH CAROLINA STATE UNIVERSITY, 4033

Economic assessment of hardwood production.

D. L. HOLLEY

The Southern pulp and paper industry's use of hardwood pulp is exhausting supplies of favored hardwood species within the normal procurement radius of some mills. This study examines hardwood management strategies for nine mixed species hardwood site types in the Southern region (Maryland to Texas). Cooperating pulp and paper companies and the North Carolina Forest Service have searched out their best natural, unmanaged, even-aged, hardwood stands, and have taken a total of 662 fifth-acre plots from which yield data are being derived. These mixed species plots cover age classes ranging from 10 to 60 years within the nine site types. Average yields in the most productive site type (black river bottoms) are below 90 cu. ft./acre/year.

The cash flow generated in the average hardwood stands sampled is less than \$2.00/acre/year, using a 6-percent interest rate and current hardwood pulpwood stumpage prices. When a charge is levied for taxes, protection, and funds tied up in land, the

net cash flow of the "leave it to nature" strategy is always negative for pulpwood production.

From a southwide survey of experimental plantings, it tentatively appears that cubic foot growth rates can be tripled on average and better hardwood sites through intensive culture of species such as sycamore and sweetgum. However, the high cost of cultural practices still results in a negative net cash flow, using current pulpwood prices.

The effects of higher prices will be examined as will be the trade-offs between extensive management strategies on company lands. The economics of sawtimber rotations will also be considered.

OREGON STATE UNIVERSITY, 833

Economics of chemical brush control.

C. F. SUTHERLAND

Results show that chemical brush control on Site IV for Douglas-fir is uneconomic for all firms if their sole objective is timber production. Chemical control may be feasible on Site III lands for firms with low alternative rates of return. For lands whose value is derived from production of goods or services other than timber, such as recreation, this analysis will give some indication of the additional cost that must be incurred to produce these other goods and services.

UNIVERSITY OF VERMONT, 14

Forest management by parametric linear programming.

F. H. ARMSTRONG

Linear programming was employed to regulate the harvest, with the uneven-aged management system, on the 78,000-acre eastern Maine tree farm owned by the Dead River Company. An objective function was used that maximized the productivity of the forest subject to continuance of the present minimum harvesting requirements. It was shown that the dual solution to the linear program states the change in the volume of the total harvest that will result from any deviation of the requirement for equal periodic volumes. A more important conclusion is that the value of the dual solution will, in this case, change in a very gradual manner and that considerable planning can be based on the given dual solution value. The 1967 remeasurement of the permanent sample plots is being analyzed to verify the volume prediction

method that was used in the early stages of this study. (fig 36).

ADDITIONAL PROJECTS

UNIVERSITY OF CALIFORNIA, 2349

Determination of optimum production schedules by mathematical programming. **D. E. TEEGUARDEN**

UNIVERSITY OF CALIFORNIA, 2447

Financially optimum thinning regimes for mixed-conifer forests of California. **R. F. GRAH**

LOUISIANA TECH UNIVERSITY, 61

Workmen's compensation and safety in forestry, Arkansas and Louisiana. **J. E. CAROTHERS**

MICHIGAN STATE UNIVERSITY, 978

Financial evaluation of forest management opportunities. **V. J. RUDOLPH**

UNIVERSITY OF MISSOURI, 166

Wood industries management. **K. T. ADAIR**

UNIVERSITY OF MISSOURI, 168

Allocation of inputs among timber production opportunities. **R. C. SMITH**

UNIVERSITY OF NEW HAMPSHIRE, 7

Economic guidelines for timber stand improvement in New Hampshire. **P. E. BURNS**

SOUTH CAROLINA-CLEMSON UNIVERSITY, 707

Logging costs. **W. A. SHAIN**

UNIVERSITY OF TENNESSEE, 10

Economics of alternative timber-growth practices in Tennessee hardwood stands. **G. R. WELLS**

UNIVERSITY OF WISCONSIN, 1571

Computer simulation of sampling designs and management practices in forestry. **L. G. ARVANITIS**

PUBLICATIONS

CAROTHERS, J. EDWIN.

Workmen's compensation and safety in southern forestry. Presented at meeting of the Southern Economics Association, Miami Beach, Fla., November 1971.



Figure 36. Residual growing stock after a selection cut on an eastern Maine tree farm.

LANFORD, BOBBY L., and WILLIAM A. SHAIN.
Shortwood or tree-length—Which costs less?
Pulpwood production and saw mill logging, pp.
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POWELL, GORDON J., and K. T. ADAIR.

Guidelines to forest estate planning, *Jour. of Forestry*
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WARE, CLENN O., and JEROME L. CLUTTER.
A mathematical programming system for the
management of industrial forests. *For. Sci.*, December
1971.

Chapter 7

MARKETING OF FOREST PRODUCTS

Quantitative aspects of marketing—demand and supply—are discussed in this chapter. Prices, results of intermixing of demand-supply factors, are also given attention. Other marketing topics include trade customs and policies, marketing administration, economics of forest transport, and economics of the forest products industries.

DEVELOPMENT OF MARKETS AND EFFICIENT MARKETING OF TIMBER AND RELATED PRODUCTS

Research Problem Area 502

Development of markets and efficient marketing of timber and related products may help to maintain the incomes and employment associated with the timber industry. Nonwood products have penetrated many traditional markets for wood materials in construction, manufacturing, shipping and other uses. Research to evaluate opportunities for market expansion through more efficient processing and marketing of timber products is essential to maintain and improve the competitive position of wood and wood and timber-related products.

SOUTHERN ILLINOIS UNIVERSITY, 70-R-11

Influence of wood color and other physical characteristics on the value of black walnut veneer.

R. S. FERELL and D. C. NESEMAN

During the months of January and February, a list was compiled of all possible buyers of black walnut logs in the six-State area—Iowa, Missouri, Illinois, Indiana, Ohio, and Kentucky—and card questionnaire was mailed to each. From the returns of the questionnaire, the number of probable sampling units was reduced to approximately 20. A letter was sent

to each, requesting permission to visit and collect data. One plant was visited for the purpose of developing a sampling procedure and model. At each of the remaining 12 locations 10-15 samples were taken. These have been coded on IBM cards and a preliminary analysis has been made. A more detailed analysis will be completed shortly.

TEXAS A&M UNIVERSITY, 1524

Requirements and distribution of wood products manufactured and used in Texas.

H. E. SORENSON, W. A. SMITH, and G. T. OLSON

Prices paid for prime roundwood were found to be affected significantly by net annual growth of softwood in the Midsouth, average annual prices of boxboard, and per capita consumption of paper and paperboard. Ninety-two percent of the differences in prices paid for pine wood in the Midsouth and Southeast were explained by differences in net annual growth of softwood and pulping capacity. Major financial problems of the Texas lumber industry involved quality and cost of labor, price competition, inventory policies, and collections. Wholesalers indicated that in terms of board feet usage in Texas, Texas southern pine lumber accounted for 24 percent, Texas hardwood about 2 percent, and southern pine lumber from other States 10 percent. Douglas-fir and other imported lumber represented 64 percent of usage. Recommendations to make Texas lumber products more competitive were:

(1) Upgrade quality of plywood to comply with requirements for interior finish grades; (2) standardize product specifications; and (3) marketing firms should coordinate sales policies with small mill suppliers to provide a more reliable source of supply.

ADDITIONAL PROJECTS

UNIVERSITY OF CALIFORNIA, 2538

Economic analysis of wood procurement systems.

W. L. McKILLOP

MISSISSIPPI STATE UNIVERSITY, 3-205-1130

Cost accounting for timber harvesting contractors.

R. R. FOIL

UNIVERSITY OF MONTANA, 210-0202

Marketing Montana lumber.

R. F. WAMBACH

NORTH CAROLINA STATE UNIVERSITY, 4022

Wood residue production and feasibility of conversion to a salable product.

D. H. J. STEENSEN and J. HEDGECOCK

PUBLICATIONS

FOIL, R. RODNEY, and BEN C. JONES.

Costing logging operations through record-keeping. Proceedings, 6th LSU-APA Timber Harvesting Shortcourse. Baton Rouge, La., 26 pp. November 8-19, 1971.

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An analysis of the chip production phase of the Texas lumber industry, Department Information Report 67-2, Texas A&M Univ., March 1967.

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An analysis of the production and marketing structure of southern pulpwood, MP-887, Texas Agr. Expt. Sta., 24 pp. 1968.

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Production, marketing and prices of southern pulpwood, DIR 68-1, Texas Agr. Expt. Sta., 43 pp. 1968.

SORESENSEN, H. B.

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SORESENSEN, H. B.

The Texas distribution of the southern pine lumber industry, Dept. of Agr. Econ. and Rur. Soc., DIR 71-9, 1971.

SORESENSEN, H. B., and J. D. McNEASE.

Wholesale marketing of Texas lumber, Dept. of Agr. Econ. and Rur. Soc., Departmental Information Rept. No. 69-5, September 1969.

SUPPLY DEMAND AND PRICE ANALYSIS—FOREST PRODUCTS

Research Problem Area 513

Improved forecasts of supply, demand, and prices of forest products are essential to more efficient and orderly planning for production and marketing. Individual producers, processing and marketing firms, and end users base decisions upon information about the forecasts of future supply, demand, and price conditions. Sound public policy of forest conservation is dependent upon such information. The forest supply industries need similar data on goods and services purchased by producers so that they may make orderly adjustments to prospective changes in supply demand and price of production inputs.

VIRGINIA POLYTECHNIC INSTITUTE, 636118

An economic model for southern industrial forest regulation.

E. F. THOMPSON

A manuscript describing the work on developing economic guidelines for loblolly pine management was prepared and submitted for publication. In addition, a paper based on the project's research, was presented to the meeting of the International Union of Forestry Research Organizations, Gainesville, Fla., in March, 1971. A new project, which will continue research in similar areas, has been prepared and submitted for approval.

UNIVERSITY OF WASHINGTON, 19

Structural change in the forest products industries of the Pacific Northwest. **T. R. WAGGENER**

This project was designed to provide supporting evidence of structural change in the forest products industries of the Pacific Northwest. Based on measurement of the number of firms, employment, and payrolls for the Washington State economy over the period 1947-1968, this investigation revealed that important structural changes have occurred. Although gross physical production has generally increased, the number of firms in the forest-based sector has decreased significantly, particularly in the smaller size classes. In most instances, total payrolls and the number of employees show a relative decline, with respect to both manufacturing and total economic activity. Basic findings indicate that the forest-based industries have declined as a contributor to aggregate employment, personal income, and, to a lesser extent, the number of business firms.

Despite an absolute decline in employment, particularly in the wood products sector, payrolls (in constant dollars) have increased in the forest-based industries by over 60 percent. This increase in salary and wages has been accompanied by a 14-percent reduction in the number of active firms. Average wages have continued to lag behind manufacturing as a whole. Stability, as traditionally interpreted under the Sustained Yield concept, depends primarily on the assumed relationship between economic activity and an even flow of timber as a raw material. Structural changes in the forest-based industries of Washington clearly indicate that economic stability cannot be expected on the basis of physical resource supplies alone. Broad economic forces have led to a

continuing shift of resources within and between economic sectors.

ADDITIONAL PROJECTS

UNIVERSITY OF CALIFORNIA, 2505

The role of oligopsony and monopoly in markets for publicly-owned timber in California. **H. J. VAUX**

NEW MEXICO STATE UNIVERSITY, 8

Economic analysis of market opportunities for New Mexico forest mill byproducts. **J. R. GRAY**

PUBLICATIONS

GRAY, JAMES R.

Feasibility of establishing particleboard plants in the Four Corners Economic Development Region. New Mexico Agr. Expt. Sta. Special Report 9. December 1971.

GRAY, JAMES R., and JOHN D. CANADY.

Feasibility of baling wood shavings and sacking sawdust in the Four Corners Economic Development Region. New Mexico Agr. Expt. Sta. Special Report 10. December 1971.

GRAY, JAMES R., and JOHN D. CANADY.

Feasibility of establishing composition wood fireplace log plants in the Four Corners Economic Development Region. New Mexico Agr. Expt. Sta. Special Report 12. December 1971.

THOMPSON, EMMETT F., and RICHARD W. HAYNES.

A linear programming-probabilistic approach to decision making under uncertainty. Forest Sci. 17(2):224-229. 1971.

Chapter 8

FOREST PRODUCTS: MANUFACTURING AND UTILIZATION

Research on forest products includes the influence of genetic and cultural factors on anatomical elements in the structure of wood and bark through the phases of mechanical and chemical conversion, assembly and finishing processes, and products in use. Research is essential to maintain a competitive position for wood and to utilize wood resources more efficiently. Increasing concern about our environment makes the role of research in forest products particularly important. Because of this concern, materials other than wood have been suggested for use in buildings. However, the substitution of nonrenewable resources for wood—a renewable resource—is likely to cause greater deterioration to the environment. We must learn how to use wood more economically in places where it is now being used and to develop new uses for wood.

PROTECTION OF PLANTS, ANIMALS, AND MAN FROM HARMFUL EFFECTS OF POLLUTION

Research Problem Area 214

Pesticides, salts, sewage, cannery, textile, and animal wastes are generally considered objectionable when they occur as pollutants. Under some conditions, they may be detrimental or cause effects detrimental to specific plants or animals.

Air pollutants such as sulfur dioxide, ethylene, and fluorides have long been recognized as harmful to vegetation. Recently, increasing importance has been attached to photochemical air pollution. Examples of plant damage are: Fluoride damage to corn, citrus, trees, and flowers; ethylene damage to cotton and orchids; and ozone damage to cotton, grapes, tobacco, and trees.

Fluorides cause a serious malady in cattle known as fluorosis. Laboratory experiments with animals show that certain irritants common in polluted air

can increase susceptibility to respiratory infection and increase mortality.

Pollutants which affect plants and animals may also affect man. Smog may cause eye irritation and increase the severity of respiratory ailments. Air borne allergens, such as pollens, cause suffering to those susceptible to them.

ADDITIONAL PROJECTS

UNIVERSITY OF MONTANA, 3004

Effects of hydrogen fluoride on pollen viability in coniferous species.

C. C. GORDON

LOUISIANA TECH UNIVERSITY, 7

Responses of selected southern tree species to specific environmental contaminants.

H. E. GARRETT

PUBLICATIONS

GORDON, C. C.

Damage to Christmas trees near Oakland, Maryland and Mountain Storm, West Virginia. Publication

Number APTD 0656, Air Pollution Control Office, Environmental Protection Agency. 1971.

GORDON, C. C.

Short-long conifer needles syndrome. Air Pollution Control Office, Environmental Protection Agency. 1971.

NEW AND IMPROVED FOREST PRODUCTS

Research Problem Area 401

The objectives of forest products research are to develop (1) lower cost products with greater desirability, serviceability, and performance, and (2) greater use of low-quality timber, little-used species, and materials now remaining as waste.

There is a continuing decline in the quality of available timber because of the lack of adequate replacements for larger and better quality trees. Demand for timber products is expected to go up 80 percent by the year 2000. Research is needed to develop ways to convert more low-grade material into useful products. Where such timber is abundant, it may be possible to establish new industries and enhance economic growth. Improved wood utilization also provides a profitable means for upgrading residual stands. Use of low-quality trees frees space for better growing stock.

UNIVERSITY OF ALASKA, 270-7503

Logging costs and economic accessibility of interior Alaska forests. R. SNYDER

Based on the data collected thus far, we have found that underutilization of equipment is a major element adversely affecting cost. Inefficient crew organization, lack of trained labor, and poor weather conditions also adversely affect utilization of equipment.

UNIVERSITY OF CALIFORNIA, 2495

Chemistry and utilization of bark.

A. B. ANDERSON

Bark particle boards have been produced by the addition of certain agents, such as paraformaldehyde, or hexamethylenetetramine to the bark particles

instead of the addition of the usual bonding and sizing agents. (fig. 37). The former agents react with the tannin (polyphenolics) in the bark during the hot press cycle, forming a bonding agent, *in situ*. The resultant bark boards have internal bond values which meet the requirements of commercial standards for wood particle board. A remarkable property of the boards is thickness swelling, representing about half of the value permitted for normal particle board. Further, while the normal wood particle board disintegrates during the boiling water test, the bark board remains intact with little swelling even after the 2-hour boiling water test. Thus, in addition to forming a good internal bond, the bonding is waterproof. Since the catechol-type of polyphenolics in barks is very reactive, it was of interest to determine the effect of other agents, such as acids, bases, and oxidizing agents. The reagents examined were paraformaldehyde, hexamethylenetetramine, nitric acid, hydrochloric acid, sodium hydroxide, ammonium hydroxide, hydrogen peroxide, ferric chloride, ammonium nitrate, and sodium chlorate. The barks investigated include white fir, Douglas-fir, ponderosa pine, and sugar pine. Each reagent reacted to form a bonding agent in the preparation of bark particle board. The correlation between specific gravity and basic physical properties of composite bark boards made with optimal reagent was determined.

COLORADO STATE UNIVERSITY, 320

Multicomponent binder systems for particleboard manufacture.

F. F. WANGAARD and H. E. TROXELL

The investigation summarized the findings of 334 experimental particleboard panels prepared using techniques similar to those used by industry and designed to evaluate various extenders for particleboard resin binders. Urea-formaldehyde and phenol-formaldehyde resins were extended with various levels of kraft lignin, Douglas fir bark, animal blood, Vinsol (thermoplastic pine resin supplied by Hercules, Inc.), and silicate of soda. All test panels were made using residue planer shavings of Rocky Mountain species.

Adequate properties were obtained from at least one formulation of all extenders for both resins; however, certain extenders performed better than others.

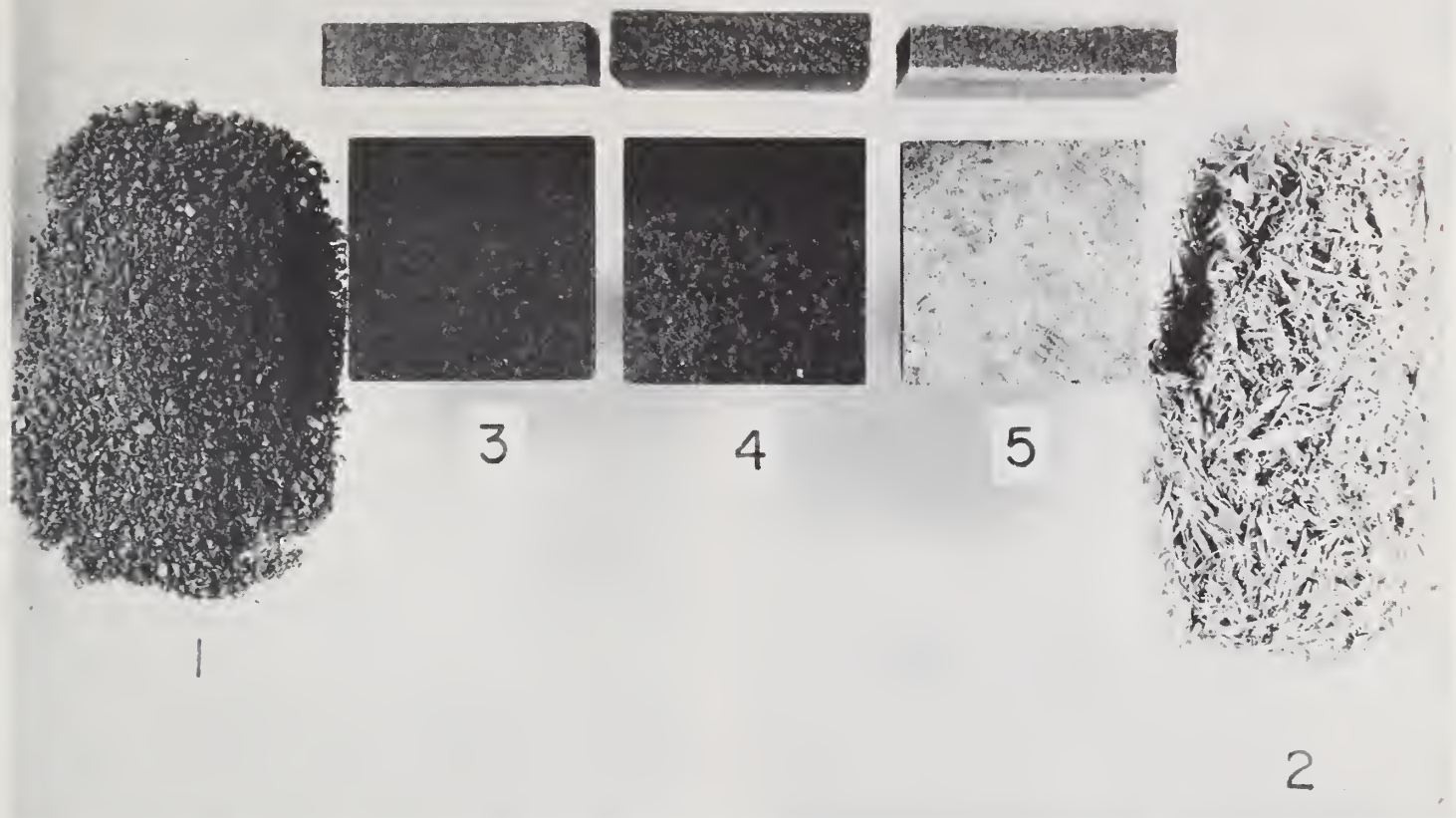


Figure 37. Bark boards have internal bond values which meet commercial requirements. 1—Bark. 2—Wood waste. 3—Bark board. 4—Bark/wood board. 5—Three-layer bark core board.

Vinsol resin, low-soluble blood, and solvent-extracted bark performed best as extenders for urea formaldehyde resin, while Vinsol resin, kraft lignin, unextracted bark, and a ready-to-use exterior plywood adhesive showed potential value as extenders for phenol-formaldehyde particleboard adhesive.

In panels where urea-formaldehyde was extended 30 percent with Vinsol resin, bark or blood, and a buffered ammonium chloride catalyst, adequate amounts of catalyst improved board properties and enabled production with press times of 4 minutes for ½-inch thick panels.

Study results indicate that sufficient information is available to pursue further the transfer to commercial application. The use of dual or multicomponent binder system for particleboard should result in reduced glue costs.

SOUTHERN ILLINOIS UNIVERSITY, 69-R-A

Effect of particle size on strength, dimensional properties, and surface roughness of hickory particleboard.
A. A. MOSLEMI

Test results indicate that particle geometry influences the various board properties in an approximately similar manner as that of other species. The panels at 42 to 45 pcf density appear to meet (and exceed) current commercial standards in mechanical properties, with exceptions of the internal bond strength. The properties with respect to liquid water absorption appear to be poor for the boards made. However, it is believed that the addition of sizing and catalyst will bring these deficient properties to an acceptable level. Further, using surface particles at a higher moisture content than that of the core (in the case of three or multilayer boards) should not only improve internal bond strength, but also promote a smoother panel surface.

Smaller particle sizes and higher board densities result in panels with smoother surfaces. The use of fibrous surface particles with higher moisture contents should produce a board surface that will meet all current surface requirements.

SOUTHERN ILLINOIS UNIVERSITY, 69-R-23

The effect of moisture cycling upon the dynamic modulus of wet and dry process fiberboard.

A. A. MOSLEMI and B. W. LIGHTCAP

This research analyzed commercial hardboard under service conditions in which the moisture in the product fluctuates over time, and compared boards made by two different processes. Two types of medium-density fiberboard (hardboard) were subjected to cyclic humidity conditions. These boards were made from the same fiber sources, but one used a wet process and the other a dry process.

The dynamic modulus of elasticity, measured by free oscillation of the material and monitored by an oscilloscope and camera system (fig. 38) was examined. This nondestructive technique provided data over three complete wet and dry cycles, ranging from 2- to 18-percent moisture content. The data indicate that the dynamic modulus was progressively reduced as the cycling advanced for both wet and dry processes. However, reductions in the former were less than in the latter. The study results revealed that



Figure 38. Oscilloscope and camera system used to examine the dynamic modulus of elasticity of fiberboard.

progressive strength reduction can be expected in hardboard as it absorbs moisture during the humid summer season and then dries in winter months.

INDIANA-PURDUE UNIVERSITY, 1355

Mechanical behavior of wood-base composite media.

M. C. HUNT

Some of the earliest examples of buildings using composite structural components of lumber frame covered with exterior plywood have been found. A forerunner of today's manufactured housing, components were first used experimentally in 1940 at Purdue to fabricate portable plywood hog houses. Exterior plywood was then a relatively new product and had not been conclusively field tested. Even in service more demanding than expected in residential housing, the integrity of the plywood hog house continues after 21 to 30 yrs. (fig. 39). Animal researchers interested primarily in pork production took the excellent performance of the units for granted, and formal records are nonexistent. In 1961, interest in the houses was renewed when they were discovered by chance during a Purdue Wood Research Laboratory field survey of plywood construction. Detailed descriptions of plywood construction and performance are being assembled to substantiate the long-term durability of exterior plywood and its use in buildings subjected to extreme weather and high



Figure 39. Portable plywood hog house in 1961 after 20 years of use. House remained in service until 1970 when it was retired because of a management shift to confined housing.

dynamic loads. Fifteen plywood hog houses, in excellent condition after 21 years of use, have been dismantled. The strength of nailed plywood-lumber joints and structural adhesive joints removed from the walls of the dismantled houses is being tested at Purdue. A sample of weathered plywood panels is being tested cooperatively with the American Plywood Association. A rare opportunity exists to observe the effects of time on plywood and the outstanding integrity of a structural system in an actual service situation.

UNIVERSITY OF MAINE, 5009

Anatomy and fundamental properties of Maine woods.

**N. P. KUTSCHA, J. F. SHOTTAFFER, and
C. SHULER**

Research has been conducted on various fundamental properties of plantation-grown red pine. One investigation evaluated the effect of dry kiln procedures on visual grade characteristics and selected mechanical properties of the wood. There appeared to be little or no effect of kiln temperature on either the magnitude or incidence of degrade, such as twist, cup, crook, or bow. Most strength properties also were not significantly affected by kiln temperature. Another investigation was concerned with the relationship of average ring fibril angle to position in the tree, late-wood percentage, specific gravity, and growth rate. Within the early wood zone, fibril orientation was obtained by measuring the alignment of flattened bordered pit apertures between ray tracheids and longitudinal tracheids, a technique which apparently has not been previously used (figs. 40 and 41).

Another area of investigation concerns the anatomical aspects of the lignification process in balsam fir. A study of the suitability of 10 stains for studying lignification by light microscopy has been completed.

MICHIGAN STATE UNIVERSITY, 1048

Measurement and analysis of hygroscopic dimensional changes of wood composite products.

O. SUCHSLAND

Furniture panels used in table tops and cabinet doors are laminates consisting of relatively thick core materials and thin decorative face layers. Hygroscopic

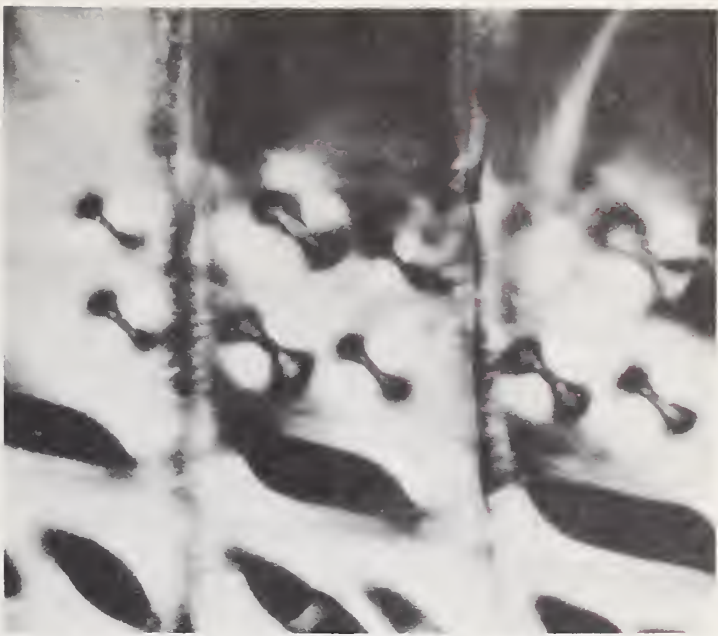


Figure 40. Alignment of bordered pits located between ray tracheid cells and longitudinal tracheids can be seen in upper half of micrograph. Half-bordered pits located between ray parenchyma cells and longitudinal tracheids can be seen in lower half of micrograph. Alignment of both types of pitting is nearly identical. Radial section, earlywood.

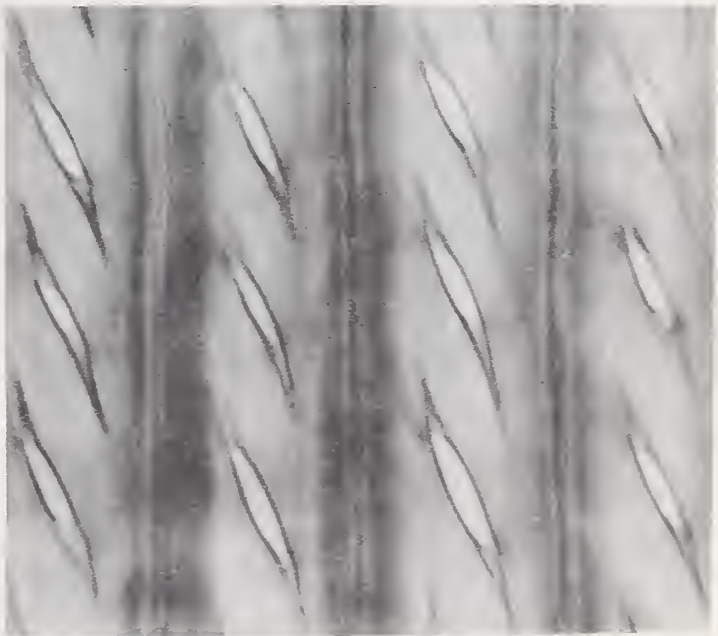


Figure 41. Alignment of half-bordered pits located between ray parenchyma cells and longitudinal tracheids. Radial section, latewood.

dimensional changes of such panels are small. However, when restrained, these changes can cause considerable stresses which, if not properly balanced, could result in such distortions as the bowing of table tops.

An optical comparator was developed and used for measuring dimensional changes of composite panels and their components. Panels using particleboard cores were found to have greater dimensional stability than those using lumber cores. The use of crossband veneers does not improve the stability of particleboard furniture panels. Figure 42 illustrates the restraining effect of the particleboard core on the mahogany crossband and walnut face veneers. The resultant expansion is somewhat less than that of the core alone, which is explained by the small expansion of the veneers along the grain and their high moduli in the same direction. The resultant expansion is not directional and is clearly determined by the core.

Other studies being conducted or planned for the future deal with thickness swelling of panel materials and the effect of certain imbalances in panel construction on panel stability.

MISSISSIPPI STATE UNIVERSITY, 3622

Preservation of southern pine poles and piling.

W. S. THOMPSON

The results of over 450 individual strength determinations on structural-size members, including 150 full-size utility poles, show that kiln-dried stock had significantly higher strength values than matched material which was steamed at temperatures and for durations permitted under current standards. Modulus of rupture (MOR) of poles at the point of maximum stress was most seriously affected; it was 37 percent less for steamed than for kiln-dried samples. Comparable differences for fiber stress at the proportional limit and MOR at the point of failure were 26 percent and 32 percent respectively. Reductions in maximum crushing strength of 1, 18, and 23 percent occurred in treated piling sections pre-steamed at 245°F for 0, 8, and 16 hours, respectively, compared with matched untreated controls. Knots and other natural defects permitted by grading standards had only a minor effect on the bending strength of poles, but had a significant effect on the crushing strength of piling. The modulus of elasticity of poles and piling was not adversely affected by steaming.

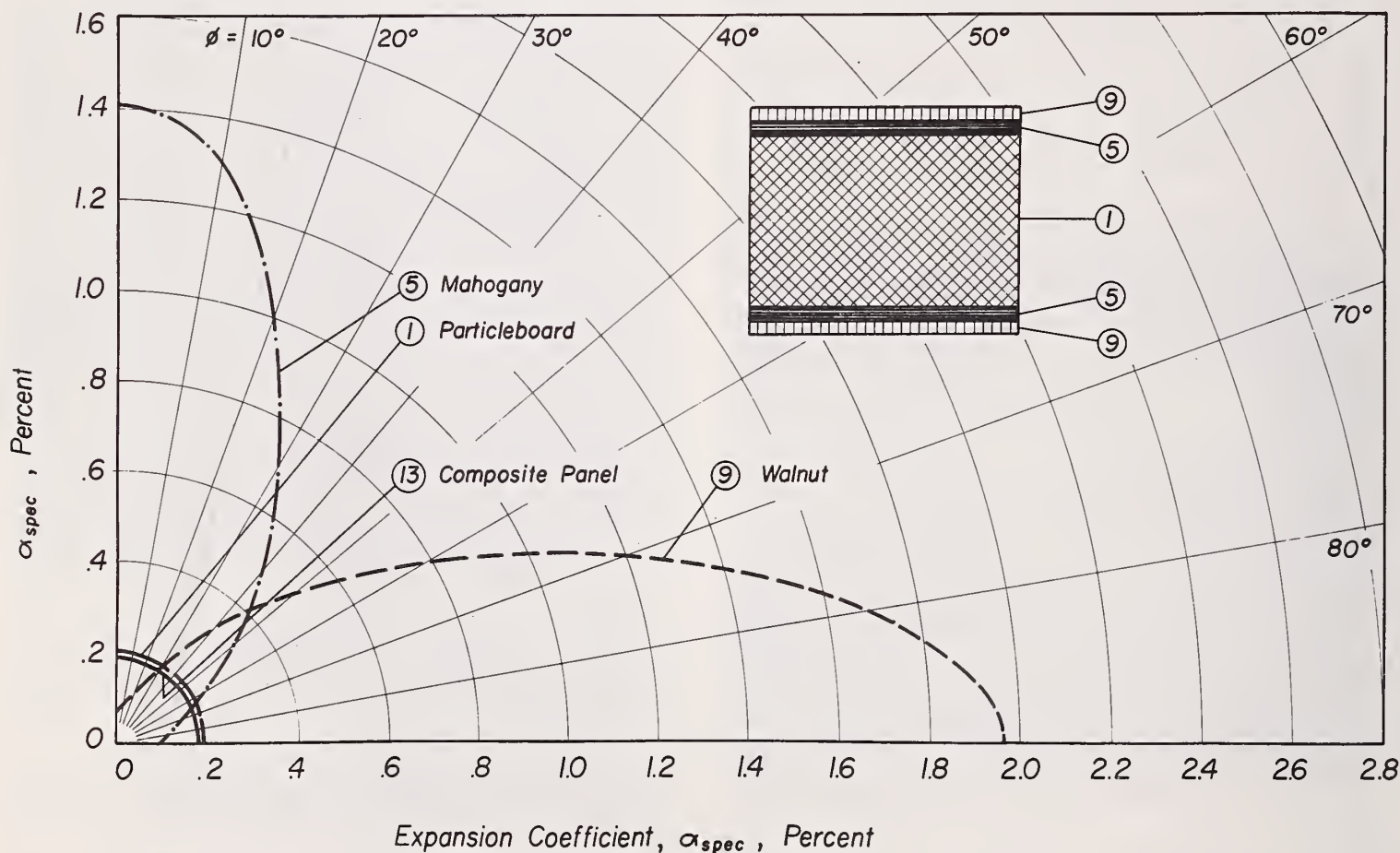


Figure 42. Illustration of straining effect of particleboard core on mahogany crossband and walnut face veneers.

Permeability tests of samples taken from pole sections that had been kiln dried to moisture contents of 20 to 50 percent, using temperatures of 150°F to 200°F, did not differ significantly from samples taken from matching sections that had not been dried.

All the carbohydrate fractions of wood underwent change as a result of steaming treatments conducted at 245°F; the degree of change increasing with longer durations of steaming ranging from 0 to 20 hours. These changes in chemical makeup were highly correlated with changes in strength. (fig 43).

Laboratory experiments and field tests of simplified accelerated drying schedules for kiln-dried southern pine poles show that drying times can be reduced up to 60 percent without affecting the acceptability of the poles from the standpoint of surface checking, end splits, wood strength, and treatability. The schedules developed employ constant dry-bulb temperatures of 160°F to 225°F and constant

wet-bulb depressions of 40° to 50°F. The schedules have been widely adopted by industry.

MISSISSIPPI STATE UNIVERSITY, 3623

Wood properties of Mississippi Delta hardwoods.

F. W. TAYLOR

Property variations of Mississippi Delta hardwoods are accumulated for use both in estimating timber quality and in planning tree improvement programs for selected species (black willow, willow oak, sycamore, pecan, and sugarberry). Specific gravity, fiber length, cellulose content, fiber dimensions, and volumetric composition were selectively sampled at points representing various heights and growth rings.

Specific gravity (influenced by the size, proportion, arrangement, and wall thickness of wood elements) varies with the age of the cambium. Four distinct patterns, ranging from an increase in specific gravity with age to a decrease with age, have been reported for different species. This study revealed that the relationship not only differs from species to species, but also may differ for varying sampling heights. (fig. 44). The fiber length-age relationship in study trees conformed to the general pattern of large increases in fiber length with age in rings near the pith, followed by a more gradual increase until a maximum is reached. Variations in fiber diameter were not great, but in all species, cell diameter decreased as height in the stem increased. Thin-walled fibers were found near the pith, while thick-walled fibers developed in the outermost growth increments. Data on volumetric

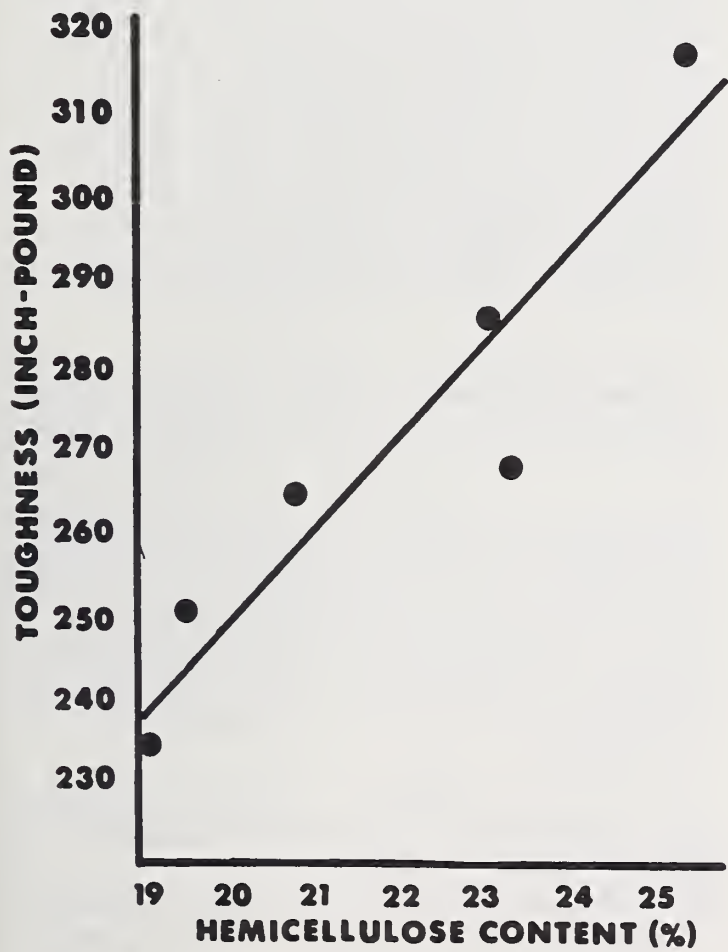


Figure 43. Relationship between strength of steamed wood and hemicellulose content.

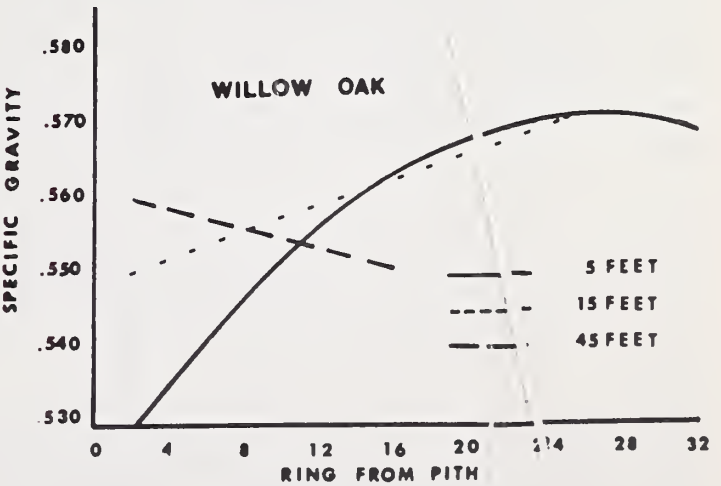


Figure 44. Variation in specific gravity of willow oak at different positions in the tree.

composition revealed large variations. The general pattern with age was a linear or curvilinear increase in vessel volume and a corresponding decrease in fiber volume as the cambium aged, while the ray volume remained constant or increased slightly with age.

MISSISSIPPI STATE UNIVERSITY, 3625

Development of wood adhesives. H. R. ROGERS

A new type adhesive for wood—Southern pine and poplar—was developed which passed the exterior test for plywood according to APA specifications. This adhesive is a phenol-melamine-formaldehyde copolymer prepared in water emulsion form at neutral or slightly acid pH. The emulsion adhesive at 40 percent resin solids has the physical characteristics of a water-base latex paint and has excellent spreading qualities. Preliminary evaluation indicates that the glue-line spread can be reduced considerably, while still maintaining an exterior glue line. The spreading characteristics of the adhesive should make it ideal for more recent means of application, such as spray or coater application.

There are many emulsifying agents capable of converting the resin into a stable water emulsion form. However, the most suitable emulsifier to date is an acid-containing, cross-linked, acrylic co-polymer.

UNIVERSITY OF NEW HAMPSHIRE, 3

Wood drying stresses and improved kiln practice.

J. L. HILL

The solution of the problem of interference encountered with continuous resistance measurement in kiln drying was found to be a repetitive, nonsymmetrical, constant current pulse as the measurement wave form. An instrument with a wood element sensor has been developed to remotely monitor moisture distribution in drying lumber and to provide automated control for lumber drying. The probe-cable capacitance is included in the resistance reading obtained by the meter. Therefore, the calibration of the meter is a function of the lead lengths of the probes. The meter is planned to interface with other commercial measuring equipment and to operate at elevated temperatures (up to 100°C) for indefinite periods without major losses in accuracy. Also, the device is simple enough so that a person unfamiliar with electronic equipment could

learn to operate it without great difficulty. Work is continuing on improving both the meter and the sensor design to achieve greater reliability and to simplify the electronics for use in drying research. The instrument is an essential sensing device for automatic kiln control.

NEW YORK—STATE COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 102-0-1

Wood properties of fertilized red pine planted on potash depleted soils. CARL DE ZEEUW

Red pine (*Pinus resinosa* Ait.) plantations established on potassium deficient, sandy glacial soils at Warrensburg, N.Y., have shown markedly poor external growth characteristics. Analysis of the wood produced by these trees reveals characteristics that significantly differ, on a statistical basis, from those of wood produced on soils containing a normal amount of potassium. A comparison of deficient trees (A) with trees receiving a normal amount of potassium (B) reveals the following: (1) Overall ring widths in A were consistently from one-third to one-half as wide as in B; (2) width of the late wood zone was 20 to 40 percent greater in A than in B; (3) cell walls were about half as thick in the early wood zone of A as in those for B, but can be shown to be 15 to 20 percent thicker in the late wood; and (4) tracheid lengths for both early and late wood zones average 10 to 15 percent longer in A than in B.

Thus, wood produced by potassium-deficient red pine trees will have longer tracheids than those of trees grown with an adequate supply of potassium, and the late wood zones will tend to occupy a large proportion of the ring width. The contrast between weight densities of early and late wood zones within the increment will be more pronounced than normal and the overall weight density will be greater than normal up to about the age of 20. Thereafter, the deficient trees will tend to produce lighter than normal wood.

NEW YORK—STATE COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 401-4-2

Formation, ultrastructure, and chemical composition on the xylem ray cells in conifers. T. E. TIMELL

The complete polysaccharide composition has been determined for ray cells from normal and

compression woods of *Pinus resinosa*. The ray cells from normal wood contained more xylan and less galactoglucomannan and cellulose than did the tracheids. They also contained a β -1,3-linked glucan not present in the tracheids. The compression wood ray cells had exactly the same carbohydrate composition as the ray cells in normal wood. This shows that the changes associated with transition from formation of normal to that of compression wood involves only the tracheids and not the ray tracheids or the ray parenchyma—an important observation.

A method was developed for isolation of a β -1,3-glucan from compression wood. Most work was done with a glucan from *Larix laricina*, which was given the name *laricinan*. It is a slightly branched polysaccharide containing glucuronic acid residues; therefore it is acidic—something which is also clear from its solution properties. Compression wood contains about 2 percent of this polysaccharide, previously referred to as cellulose. It was also isolated from *Picea rubens* and *Abies balsamea* compression woods. The results show that on pulping compression wood, the highest cellulose yield is only 30 percent. A xylan and a glucomannan were isolated from the same compression wood. Compared with normal wood xyans, that in compression wood had only half the number of arabinose side chains. The glucomannan had the same structure in the two woods.

NORTH CAROLINA STATE UNIVERSITY, 4008
Sizing of paper and paperboard. C. G. LANDES

A prototype model of a modified conductivity apparatus was constructed and a preliminary evaluation made. The effects of fluid head and endpoint current variations were also evaluated. Tests on various paper samples with different penetrating fluids have shown that repeatable and consistent results can be obtained. Additional studies of theoretical and practical considerations are required before conclusions can be made on the value of the instrument.

NORTH CAROLINA STATE UNIVERSITY, 4024
Photoinduced modifications in the structure of lignin.
K. P. KRINGSTAD

Lignin, the polymeric aromatic component of wood, which cements the cells together and gives wood its stiffness, is strongly light-absorbing. On exposure to light of wood or high-yield pulps which still contain much lignin, considerable discoloration takes place because of the lignin. Research was conducted to determine why and how lignin is “yellowed” when exposed to sunlight.

Detailed information was obtained on the nature of structures in the lignin that absorb ultraviolet light. The carbonyl groups in the lignin side chain directly adjacent to the aromatic ring are mainly responsible. Colored compounds are formed by this light absorption similar to those formed during the oxidation of phenolic materials. The necessary conditions for discoloration are ultraviolet radiation, oxygen, and phenolic structures.

Knowledge of the mechanism of discoloration made it possible to increase the photostability of lignin by reducing the carbonyl groups to the corresponding alcohols. Catalytic hydrogenation and sodium borohydride reduction of lignin resulted in improved stability toward photoinduced reactions and discoloration.

PENNSYLVANIA STATE UNIVERSITY, 1823
Rheology of wood cellulose in situ.
W. K. MURPHEY, F. C. BEALL, and
L. E. RISHEL

The configuration of the cellulose microfibril has been considered to be rectangular. This shape, however, does not provide a good basis for describing results obtained by others for measurements made of cellulose in electron micrographs. A hexagon cross section is proposed. This shape more closely fits the X-ray diffraction evidence.

OREGON STATE UNIVERSITY, 763
Differences in anatomical and chemical characteristics of permeable and refractory western hemlock.
R. L. KRAHMER and R. T. LIN

This study investigated the anatomy, air and liquid permeability, coefficients for moisture diffusion, and effect of solvent extraction on the properties of western hemlock wood that could be segregated into sapwood, normal heartwood, and wet pocket

heartwood. Wet pockets are zones in the heartwood that have very high moisture content, compared with normal heartwood, and cause problems in drying hemlock lumber to uniform moisture content. For example, normal heartwood had an average moisture content of about 65 percent, compared with an average of 150 percent for wet heartwood.

The oven-dried density of wood from wet pockets was found to be higher than that from normal wood. This density difference could be attributed to a significantly higher extractive content in the wet zone, large deposits in cell cavities, and coatings lining the cell walls and bordered pit membrane. The major extractives were compounds classified as lignins.

Average permeability and diffusion rates were found to be highest in sapwood, with normal heartwood slightly more permeable than wet wood. Initial liquid permeability of wet wood was in the same order of magnitude as green sapwood, but a very sharp decrease in permeability with time of the wetwood was observed. Sapwood and normal heartwood permeability remained relatively constant over short periods of time. Initial paths in the wood for liquid flow were thought to be opened during the initial period of flow. However, the openings became occluded with the waterborne extractives as the fluid continued to flow, causing a sharp decrease in permeability in the wet wood zones.

An unsteady state technique for measuring permeability was developed and will be evaluated as a method for determining the treatability of wood. Partial removal of lignins by extraction with acetone or benzene alcohol resulted in improving both permeability and drying rate. Treatment of green wood with dynamic compression did not improve permeability or drying rate.

VIRGINIA POLYTECHNIC INSTITUTE, 636119
Accelerated seasoning of large-dimension wood products. R. E. MARTIN and G. IFJU

In this study, the term seasoning was used in the broadest sense of the word; that is, movement and equilibrium of various fluids in wood (and bark). Many basic phenomena concerning the relations of wood (and bark) with various fluids were measured in specimens large enough so that properties of the

material are significantly influential in comparison with boundary conditions. Experimental work on the "stress relaxation" phenomenon in wood was conducted. Difficulties were experienced in the techniques used, but the data should hopefully yield significant results.

Work was also done on developing techniques for measuring sorption of oil and kraft digester gases by barks. Bark sorbed up to four times its weight in oil, the sorption dropping off significantly with particle size and somewhat with moisture content. The cold water pollution from bark was also measured, as this would be a side effect in any use of bark to remove oil from water.

Bark was found to be an excellent sorber of kraft digester gases-hydrogen sulfide, dimethyl sulfide, and the mercaptans. Both packed filters and continuous feed filters were successful.

VIRGINIA POLYTECHNIC INSTITUTE, 636160
Effects of steam treatment on the structure and properties of red oak wood. G. IFJU

Small specimens of red oak heartwood were subjected to steam treatments at atmospheric pressure for 1.5, 3, 6, 12, 24, 48 and 96 hours. Short steaming induced little or no changes in the properties and composition of red oak. Prolonged steaming up to 96 hours, however, resulted in significant changes in physical and mechanical properties as well as in structure and chemical composition of wood. After 96 hours of steaming, volumetric shrinkage to the air-dry condition was 4.4 times that of the nontreated wood, indicative of cell wall collapse. The color of the wood was darker and the expressed fluid content brighter with prolonged steaming.

Fiber stress at proportional limit and the modulus of elasticity in transverse compression were reduced 35 and 58 percent respectively after 96 hours when tested at the initially high moisture content. Fiber stress at proportional limit was almost completely recovered when wood was air-dried. Modulus of elasticity exhibited a less complete recovery. After rewetting, the original reduction became apparent again and was even intensified by additional strength losses imposed by the drying and rewetting processes. After 96 hours of steaming, fiber stress at

proportional limit at initially high moisture content was reduced to about 21 percent of its nontreated control. Respective values of modulus of elasticity were lower in the tangential (13.5 percent) than in the radial direction (32 percent).

Microscopic investigations indicated that long steaming made wood fibers swell internally in the direction of the lumina (see fig. 45). Similarly, a significant internal shrinkage resulted in the lumen direction upon drying of steam-treated red oak.

Increased internal swelling can explain the considerable strength reductions in water-saturated conditions, and increased internal shrinkage may be responsible for both the increased external shrinkage and the almost full recovery of strength properties in the air-dry condition. The latter also seems to be a factor in cell wall collapse.

UNIVERSITY OF WASHINGTON, 24
Minimizing deterioration of exposed structural wood members.
H. D. ERICKSON

More than 12 buildings in the Puget Sound area with exposed laminated beams were examined, and the reasons for the deterioration studied. A school auditorium was studied in detail. Some beams had

decayed between the side plates and even above this zone. The rotted wood had been cleaned out, the cavities filled with epoxy resin, and the beam encased with fiber glass. However, serious decay followed within 2 years. A special injection system was used to treat the surrounding wood with a water soluble preservative. Specially designed covers were installed to allow drying of the beams in 1 year. Periodic moisture readings showed a gradual decrease in moisture content to a safe level below fiber saturation point. The decayed areas were then filled with epoxy resin to maintain strength of the arches. Another case study showed that filling decayed zones with concrete permitted continuation of decay. Five fungi were isolated from decaying beams, four of which are species of brown rot of the genus *Poria*.

The results show that water repellent treatment of laminated beams will not eliminate the possibility of decay. Enclosure of the base of arches within steel butt and side plates tends to favor decay. Once decay starts, the increased water storage it offers will accelerate decay. Sapwood in the laminations contributes to the decay hazard in the basal area. Filling decayed pockets with some inert material does not prevent further decay. Decaying beams must be protected from water and allowed to dry to a safe level. In-place treatment is possible but not very

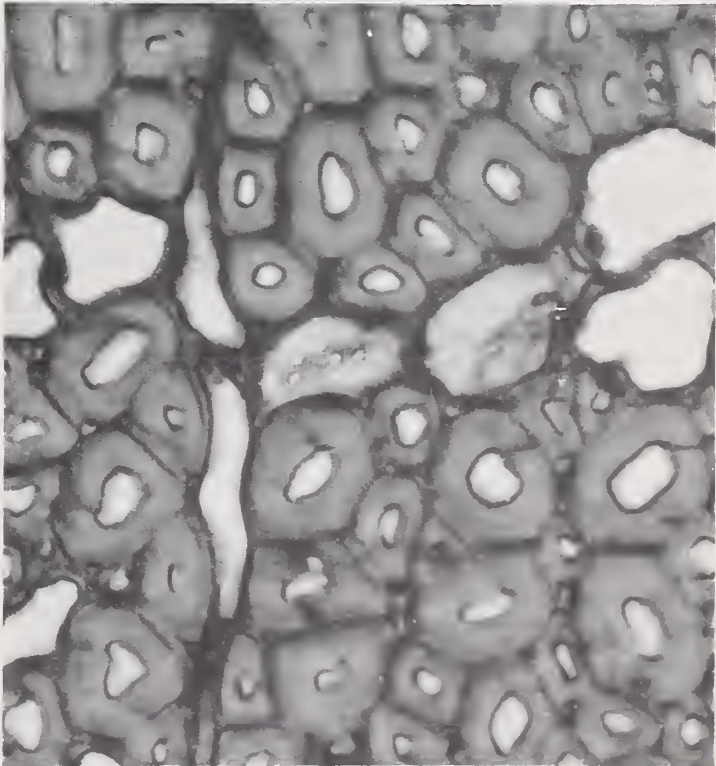
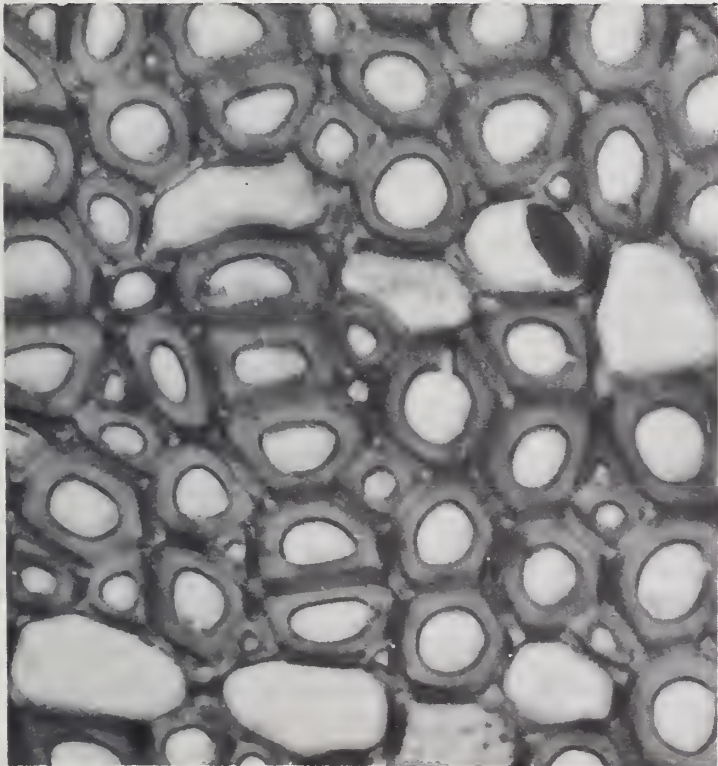


Figure 45. Wood fibers swell internally with long steaming and shrink upon drying.

successful. Improved architectural design can help to eliminate decay hazard where exterior beams and arches are desired.

UNIVERSITY OF WASHINGTON, 9

Surface properties of wood of conifers to gluing.

B. S. BRYANT

An adhesive system which showed molecular stability after mixing for several hours was formulated. This mixture of sodium silicate and "Cabosil" was used to simulate an adhesive mix which exhibits the gel characteristics of a plywood adhesive. Cohesive strength is developed when water is lost to the substrate, permitting the adhesive system to be used to evaluate the wettability-permeability properties of wood surfaces. Tension normal-to-the-glue-line, using cross-laminated veneer specimens at 5, 25, 50, and 80 minutes assembly times, provided a basis for evaluating Douglas-fir and southern pine substrates. Heartwood-sapwood and springwood-summerwood differences within and between these species were also measured. Southern pine is more wettable and permeable than Douglas-fir, as indicated by rate of cohesive strength development which, under comparable conditions, is 1.2 times greater in pine. Springwood interfaces permit cohesive strength development about 3.6 times faster than summerwood in southern pine. The sanded (new) surface develops cohesive strength in the uncured glued line about 2.9 times faster than the original (old) surface in pine, and about 6.3 times in Douglas-fir, using the standard adhesive mix.

UNIVERSITY OF WASHINGTON, 13

Mathematics of fiber assemblages.

G. G. ALLAN

This research project studied the fundamental mathematical aspects of the geometry of fibers and nonwoven assemblages. Meaningful guides were developed for the prediction of nonwoven properties by considering the geometry of the constituent fibers and the polygonal structures formed in the formation of webs. The rigidity of polygons decreases with the number of sides, and an expression for the extensibility of polygonal structures was formulated. Similarly, the stiffness of fibers is related to the cross-sectional shape, and relative stiffnesses were calculated and graphically illustrated at equal fiber areas and perimeters. Additionally, fiber parameters

of strength, collapsibility, adhesivity, and bulk were considered for hollow fibers which are less flexible than their solid counterparts. Fiber collapse improves the conformability and flexibility of the fiber which, with a concomitantly larger perimeter, provides for better surface-to-surface contact and bonding strength. Fiber collapse was considered analogous to the buckling of thin-walled cylinders with critical pressures being dependent upon the shape, elastic modulus, and fistularity of the fiber. Thus geometrical design is an important phase in the intelligent construction of fibers and their assemblages. The physical properties of bonded webs are also dependent upon the geometric characteristics of the binder and its distribution. Two novel bonding techniques were developed which would allow control of the size, shape, location, and amount of binder applied to a fiber assemblage. One method consists of impregnating the fiber mass with a polymer latex and then deactivating the emulsifier by a radiation-triggered reaction to cause selective coagulation of the polymer in an image corresponding to the pattern of the incident light. A second method for the nonrandom location of binder was developed using polymeric beads containing finely divided magnetic material. These beads could be magnetically located by manipulation with permanent magnets. Both techniques may be applicable to commercial processes and should facilitate the study of polymer fiber interactions.

WASHINGTON STATE UNIVERSITY, 1772

Dynamic strain and piezoelectric effect in wood.

R. F. PELLERIN

This research showed that the piezoelectric effect in wood detects the presence of mechanical strain which results from an impact and that the rate of propagation of such a strain wave in wood is a reliable indicator of the basic property—modulus of elasticity. Hence, a combination of these would provide a useful, nondestructive test for wood. The nature of the wave propagation also provides a unique possibility for measuring incremental values of modulus of elasticity along the length of a specimen. However, the heterogeneity and anisotropy of wood cause localized discontinuities in the strain wave front. These discontinuities, in turn, result in erroneous measurements of modulus of elasticity. To remedy this, research effort was devoted to various

ways of detecting the wave front to override the localized discontinuities. A two-pronged pickup was developed from which the leading edge of the strain wave is monitored by the first response from the pickup. The two-pronged pickup is feasible since it is highly improbable that both probes will be affected simultaneously by a discontinuity in the wave front. Also, a discontinuity in the wave front can only cause a delay in receiving a signal from that location, therefore assuring that the first signal received from the pickup is caused by the true wave front. Increased sensitivity of the pickup has also improved the measured values of modulus of elasticity over short increments.

WASHINGTON STATE UNIVERSITY, 1942

Influence of wood structure on shear strength of Douglas-fir.
A. F. NOSKOWIAK

The research results, although negative in character, have provided more information on the mechanical properties of wood. Earlier studies delineated the wood strength properties of Douglas-fir into Coast and Interior types, with Coast type recognized as the stronger wood. A 1961 reevaluation of the strength properties of Douglas-fir indicated that the strength properties of Coast wood were again higher than Interior wood, except shear strength, which was higher for Interior wood.

The objective of this project was to determine whether the anomalous result for shear strength could be related to a characteristic of wood structure. Since the presence of rays produces discontinuities in grain alignment, a test was made of the hypothesis that ray frequency is correlated inversely with shear strength in the radial plane. Tangential shear is influenced by location in spring- or summerwood zone. To eliminate the influence of specific gravity, rings per inch, and their product, a four-variable multiple regression analysis of data was performed with a computer, which isolated specimens whose radial shear strength could not be explained by these three factors. Seven specimens from Coast-type wood and 23 from Interior were identified. Two measurements of ray frequency were made on a tangential section cut from each of six 1-centimeter cubic blocks removed from each of the 30 computer-selected specimens.

The results were negative. In future studies concerning the shear strength properties of wood, the influence of ray frequency need not be considered, at least insofar as its effect on radial shear strength is concerned.

WEST VIRGINIA UNIVERSITY, 8

The formation and properties of particle board using wood-polymer composites.
J. R. HAMILTON

Initial investigations have demonstrated the technical feasibility of making mat-formed flake board using a wood-polymer composite. Experimentation, which was concerned principally with the technology of board formation, used red oak flakes impregnated with tertiary-butyl styrene, different degrees of polymerization, and supplemental adhesive applications.

It was found that the flake-monomer combination could be completely polymerized during pressing or in a tumbler prior to pressing, but, in addition, partial polymerization could be obtained by careful control of cure conditions. Experimental boards, which had some degree of integrity, were made using flakes wet with unpolymerized monomer and flakes in which the monomer was partially polymerized but not with the completely polymerized monomer-flake composite. Apparently, the pressing conditions investigated thus far (200° F to 350° F and 12 to 60 minutes) were not sufficient to cause polymer flow and thus an interparticle bond. Some degree of *in situ* polymerization was required to obtain even minimal interparticle bonding. Board density and hardness and, to some degree, moisture resistance were directly related to monomer loading.

Incorporation of adhesives enhanced the properties of boards made from unpolymerized and partially polymerized flakes and improved the integrity of boards made from completely polymerized chips. The principal adhesive used thus far has been an aqueous mixture of a thermosetting urea formaldehyde. Although not carefully evaluated, the hydrophobic nature of the polymer does not appear to completely prohibit the formation of an interparticle polymer-adhesive bond.

ADDITIONAL PROJECTS

ALABAMA—AUBURN UNIVERSITY, 910

Strength of plastic-overlaid pine plywood and particleboard. E. J. BIBLIS

ALABAMA—AUBURN UNIVERSITY, 914

Mineral composition of figured and unfigured wood. H. O. BEALS and E. S. LYLE, JR.

NORTHERN ARIZONA UNIVERSITY, 2

Wood quality of southwestern ponderosa pine in relation to growth characteristics. G. VOORHIES

CALIFORNIA—HUMBOLDT STATE COLLEGE, 24

Diameter shrinkage of logs in storage. D. L. ADAMS and R. A. HURSEY

UNIVERSITY OF CALIFORNIA, 2181

Wood machining process. F. E. DICKINSON

UNIVERSITY OF CALIFORNIA, 2553

Heating methods in the drying of wood. D. ARGANBRIGHT

COLORADO STATE UNIVERSITY, 322

Properties of lodgepole pine infected by dwarf mistletoe. D. L. CREWS

UNIVERSITY OF GEORGIA, 15

Improvement and evaluation of particleboard for exterior exposure. J. T. RICE

UNIVERSITY OF IDAHO, 15

A problem analysis of precision thin-sawing. K. SOWLES

UNIVERSITY OF ILLINOIS, 334

Penta-treatment and strength of Douglas-fir. C. S. WALTERS

UNIVERSITY OF ILLINOIS, 336

High-pressure treatment of red oak and white oak.

C. S. WALTERS

SOUTHERN ILLINOIS UNIVERSITY, 70—R—5

*Fiber-tracheid characteristics in *Ailanthus altissima* mill.*

A. A. MOSLEMI

UNIVERSITY OF KENTUCKY, 602

Glued wood corner joints of high strength.

D. B. RICHARDS

UNIVERSITY OF KENTUCKY, 1028

Wood fiber mechanics. R. C. TANG

UNIVERSITY OF KENTUCKY, 1029

Composite pole laminates. R. C. TANG

LOUISIANA STATE UNIVERSITY, 1440

Liquid and gas permeability of wood as an indication of treatability with creosote and copper sulfate.

E. T. CHOONG and P. J. FOGG

LOUISIANA STATE UNIVERSITY, 1477

Construction and evaluation of a fluidized bed for drying green southern pine wood veneer. W. E. LOOS

LOUISIANA TECH UNIVERSITY, 3

Bark residues as soil conditioner. O. L. FITZGERALD and J. W. WRIGHT

UNIVERSITY OF MAINE, 5004

Maine wood properties and grades for production utilization.

J. E. SHOTTAFAER, T. J. CORCORN, and C. E. SHULER

UNIVERSITY OF MASSACHUSETTS, 3

Rheology of wood restrained from swelling. R. B. HOADLEY

UNIVERSITY OF MASSACHUSETTS, 4

Properties of wood from northeastern tree species. H. E. GATSLICK, W. W. RICE, and W. S. McNAMARA

UNIVERSITY OF MICHIGAN, 20
Site and wood quality in upland hardwoods.
R. ZAHNER

MICHIGAN STATE UNIVERSITY, 980
Hardwood utilization and marketing.
O. SUCHSLAND

MICHIGAN TECH UNIVERSITY, 3118
The feasibility of a particleboard core sandwich type composite transport trailer deck. G. A. HESTERBERG,
B. C. SUN, and C. A. TRIPHAHN

UNIVERSITY OF MINNESOTA, 19-56
Characteristics and potential of freezing as pre-treatment for accelerated drying of important species.
R. W. ERICKSON

UNIVERSITY OF MINNESOTA, 19-60
Properties, production, and trade acceptance of aspen studs. R. D. THOMPSON, R. A. SKOK, and
R. H. HOSSFELD

UNIVERSITY OF MINNESOTA, 19-62
Methods of improving and predicting the long-term behavior of particleboard.
J. G. HAYGREEN and R. O. GERTJEJANSEN

MISSISSIPPI STATE UNIVERSITY, 3624
Efficiency lumber manufacture.
W. S. THOMPSON and W. R. FOX

MISSISSIPPI STATE UNIVERSITY, 3628
Variables affecting quality of preservative treatment of poles and piling. W. C. KELSO

MISSISSIPPI STATE UNIVERSITY, 3636
Laminated hardwood lumber for furniture manufacture. J. YAO

UNIVERSITY OF MISSOURI, 165
Anatomy and properties of Missouri woods.
E. A. MCGINNES, JR.

UNIVERSITY OF MONTANA, 3003
Chemistry, distribution and biosynthesis of flavanoids in wood. F. SHAFIZADEH

NEW YORK-STATE COLLEGE OF FORESTRY
AT SYRACUSE UNIVERSITY, 401-3-12

Neutron activation analysis of wood and treated wood.
J. F. SIAU and J. A. MEYER

NORTH CAROLINA STATE UNIVERSITY, 4005
Wood fiber properties and paper quality.
A. C. BAREFOOT and R. G. HITCHINGS

NORTH CAROLINA STATE UNIVERSITY, 4027
A fracture model for wood with localized defects.
R. G. PEARSON

NORTH CAROLINA STATE UNIVERSITY, 4029
Isolation and characterization of cellulase lignin.
H. CHANG and E. B. COWLING

OREGON STATE UNIVERSITY, 812
Electrical properties of wood below radio frequency.
R. T. LIN

OREGON STATE UNIVERSITY, 825
Environmental and genetic effects on pulping characteristics of Oregon woods.
W. J. BUBLITZ and M. D. McKIMMY

PENNSYLVANIA STATE UNIVERSITY, 1625
Increasing the operating efficiency in forest products industries. P. C. KERSAVAGE

PENNSYLVANIA STATE UNIVERSITY, 1869
A thermogravimetric analysis of adhesive and wood fiber behavior.
F. C. BEALL, W. K. MURPHEY, and
G. ZIEGLER

SOUTH CAROLINA-CLEMSON UNIVERSITY, 888
Relationship of longitudinal permeability to traumatic tyloses of Appalachian hardwoods.
T. E. WOOTEN

SOUTH CAROLINA-CLEMSON UNIVERSITY, 925
Wood properties of trees selected for Clemson University's superior tree program. T. E. WOOTEN

UNIVERSITY OF TENNESSEE, 9
Hardwood characteristics. H. A. CORE

TEXAS A&M UNIVERSITY, 1650

Potential Formosan termite damage in Texas and an evaluation of control methods. A. E. LUND

TEXAS A&M UNIVERSITY, 1733
Chemical utilization of southern yellow pine bark.
D. F. DURSO

VIRGINIA POLYTECHNIC INSTITUTE, 636175
Structure and physical-mechanical properties of eastern tree barks related to their utilization.
R. E. MARTIN and G. IFJU

UNIVERSITY OF WASHINGTON, 15
Solution of problems in orthotropic and anisotropic elasticity.
B. A. JAYNE

WEST VIRGINIA UNIVERSITY, 2
Growth rate and specific gravity of hardwoods.
J. R. HAMILTON

WEST VIRGINIA UNIVERSITY, 3
Utilization of sprout black cherry. C. B. KOCH

UNIVERSITY OF WISCONSIN, 1518
Avoiding checks in wood and wood products.
H. J. KUBLER

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IMPROVEMENT OF GRADES AND STANDARDS OF FOREST PRODUCTS

Research Problem Area 512

Grades and standards describe the characteristics of a product so that producers and processors, and buyers and sellers can gauge product utility. Tree grades provide a means of more effectively valuing growing stock, thus assisting the producer to set specific goals for silvicultural practice and to obtain true value for

stumpage. Log grades reduce the uncertainty in product transactions and permit segregation of logs for their highest use, to the benefit of both buyer and seller. Standards for processed forest products likewise assist buyers in obtaining product characteristics they desire and sellers in obtaining appropriate compensation for what they sell. Because wood is by nature a very heterogeneous material, the efficiency of the whole structure of wood markets depends to a large degree on the existence of accurate and understandable grades and standards.

WASHINGTON STATE UNIVERSITY, 1929

Factors affecting the vibrational parameters of structural lumber.
R. F. PELLERIN

This past year's research effort has involved the study of the ability of vibrations to determine the degree of grain deviation in structural lumber. The slope of grain in structural wood members is a very important factor controlling the strength of those members. Therefore, the ability to assess the degree of grain deviation in wood members is desirable for any system that nondestructively evaluates these members for strength properties. The general slope of grain, which is commonly known as spiral grain, is most difficult to measure and has a great influence on the ultimate strength of a wood member. Spiral grain is the case in which the fibers in the wood lie at an angle to the longitudinal surface of the stem of the tree. Research results involving transverse vibration reveal that although the frequency of vibration is influenced by spiral grain, the degree of spiral grain is indeterminable. Longitudinal vibrations, however, show promise for determining the degree of grain deviation. Research studies involving longitudinal vibrations have shown that wave propagation along the grain travels four to five times faster than across the grain. (This ratio corresponds to the values of modulus of elasticity measured both with and across the grain of wood.) Therefore, a longitudinal vibration which is coupled to a wood member will form a wave front which is influenced by the degree of grain orientation. Hence, by monitoring the shape of the wave front, the degree of grain deviation may be determined.

ADDITIONAL PROJECTS

UNIVERSITY OF CALIFORNIA, 2357

Marketability of veneer and plywood from young-

growth California pines and redwood.

F. E. DICKINSON

UNIVERSITY OF KENTUCKY, 601

Improved hardwood log breakdown.

D. B. RICHARDS

UNIVERSITY OF WASHINGTON, 23

Models for wood quality-processing problems.

J. S. BETHEL

HOUSING

Research Problem Area 801

Housing, as individual units and collectively, has a significant impact on the quality of rural living. Tremendous opportunities exist for research to reveal effective, economical procedures and materials for renovating and modernizing existing houses as well as in design and development of new housing.

UNIVERSITY OF KENTUCKY, 1015

Use of Appalachian Timber.

O. M. DAVENPORT and J. N. WALKER

The use of integral equations to define stress distribution in wood has been expanded and a number of prototype beam systems having discontinuities—both internally and along the upper and lower boundary—have been examined. These results have been compared with values obtained by use of orthotropic stress functions. The integral equation approach appears to generate values which are realistic as the system parameters are varied. This does not hold true for the values obtained by use of the orthotropic stress functions.

ADDITIONAL PROJECTS

INDIANA—PURDUE UNIVERSITY, 1353

Analytical design of trussed rafters.

S. K. SUDDARTH

PUBLICATIONS

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ALLEVIATION OF SOIL, WATER, AND AIR POLLUTION, AND DISPOSAL OF WASTES

Research Problem Area 901

Soil, water, and air are being polluted with a variety of substances, both inorganic and organic. Some of the more apparent contaminants are organic pesticides, radionuclides in fertilizers, growth regulating chemicals, animal and crop wastes, mulching materials, pathogenic microorganisms, heavy metals, salts used on roads for de-icing, lead from fuel combustion, allergins, and radioactive fallout. Agricultural research must be primarily concerned with alleviating pollution initiated by agricultural and forestry practices.

NEW YORK-STATE COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 901-0-3

Fertilization-water quality; a review, analysis, and evaluation.

A. L. LEAF

Questions on the effects of fertilizers on environmental quality involve the use of chemicals for increasing wood-fiber production, wildlife-habitat manipulation, and recreation-site development that might enter streams and affect water quality. Because of the interdisciplinary nature and complexity of the plant-soil-water system that must be considered in answering these questions, a comprehensive review, analysis, and evaluation of available information is necessary. The current project, about half completed, attempts to achieve this objective.

To date, over 1,000 references have been collected in several major topical areas: problem identification, natural nutrient cycling, water volumes, fertilizer use on lands, nonwater pathways of fertilizer nutrient additions, and losses of fertilizer nutrient additions through water pathways. Each major topic includes numerous subdivisions for ease and clarity in organizing the material. The final product of this

project will be comparable with the forest fertilization review by Mustanoja and Leaf (1965).

NORTH CAROLINA STATE UNIVERSITY, 4025 *Pulp industry pollution abatement through process modification.*

H. CHANG, K. P. KRINGSTAD, and W. T. McKEAN

This research project was undertaken to eliminate the obnoxious odors produced during the Kraft pulping operation. Two distinct approaches have been taken. One approach is in-digester oxidation of Kraft black liquor with oxygen, which was designed for odor reduction in the existing pulp mills. Injection of about 5 percent oxygen into the digester at the end of the Kraft cook greatly reduces the odor formation without affecting either the yield or the strength properties of the pulp.

The other approach is delignification with oxygen and alkali, which is inherently free of air pollution problems if successfully developed. It has been found that high quality pulp can be produced by delignification with oxygen and alkali from a high lignin containing pulp. However, attempts to delignify wood chips were not successful. Thus, wood chips may have to be defiberized before delignification with oxygen and alkali. This two-stage process may become a new alternative to the existing Kraft-pulping process.

ADDITIONAL PROJECTS

MICHIGAN TECHNOLOGICAL UNIVERSITY, 2-3210

Effect of pulp residual hemicelluloses on cyclic-dried paper strength. **B. C. H. SUN and G. A. HESTERBERG**

NORTH CAROLINA STATE UNIVERSITY, 4028

Water reuse in pulp and paper manufacturing.

C. N. ROGERS

TEXAS-STEPHEN F. AUSTIN STATE UNI- VERSITY, 5

Land disposal of pulp mill effluent.

K. G. WATTERSTON

TEXAS-STEPHEN F. AUSTIN STATE UNI- VERSITY, 8

Air pollution in East Texas due to prescribed burning.
H. C. REEVES

PUBLICATIONS

CHANG, HOU-MIN, WILLIAM T. McKEAN,
RANDALL D. SHIRLEY, and STEVEN SEAY.

*Delignification by oxygen and alkali. Proceedings of
the TAPPI 25th Alkaline Pulping Conference, pp.*
123-132. 1971.

KRINGSTAD, KNUT P., WILLIAM T. McKEAN,
JAN LIBERT, PEDER J. KLEPPE, and CHEU
LAISHONG.

*Odor reduction by in-digester oxidation of Kraft
bleach oxygen. Proceedings of the TAPPI 25th
Alkaline Pulping Conference, pp. 29-54. 1971.*

LEAF, A. L., and R. E. LEONARD.

*Forest fertilization and/or water quality. Southern
Lumberman 221:90-91. December 15, 1970.*

Chapter 9

FORESTS AND FORESTRY FROM THE NATIONAL POINT OF VIEW

Public concern for the environment and the effects that man is having on the environment has never been greater. A major focus of this concern is on our forest resources. The demand for greatly increased reservations of forest areas for recreational use by a rather select group is in direct conflict with the long-standing need for expanded timber harvest to provide more and better housing for a large segment of the population. The intricacies of these opposing forces and their points of view create enormously complex problems in developing forest policy. Solutions will not be found in adoption of simple alternatives of more timber or more recreation. Well planned combinations or compromises, based more on facts and less on emotion, must be developed.

ALTERNATIVE USES OF LAND

Research Problem Area 104

Alternative uses of land need to be evaluated to determine which ones will provide the greatest short- and long-range social and economic benefits. Population growth, advances in agricultural technology, changing consumer demands, urban and suburban growth, needs of people at home and abroad, recreational needs, and other factors result in changing demands upon our nation's fixed supply of land. Soil conservation and water, watersheds, recreation, and community development programs and policies should be based upon the relative advantages of alternative land uses.

ADDITIONAL PROJECTS

UNIVERSITY OF DELAWARE, 715-E

Wild-land ecology and urban impact.

R. E. JONES and R. R. ROTH

PUBLICATIONS

DAVIS, VIVIE E.

Effects of cowbird and blow flies on wood thrush nestling growth and development B.S. thesis, University of Delaware 17 pp. 1971.

OUTDOOR RECREATION

Research Problem Area 902

Outdoor recreational research provides information to guide the use and management of forest and rural lands for recreation, and to help coordinate this use with other land resource uses. The research involves problems in management of the resource and socioeconomic relationships of users to the resource. Recreation demands continue to increase, and are becoming more varied and more complex, at a time when pressure on all land resources is accelerating.

SOUTHERN ILLINOIS UNIVERSITY, 69-R-018
*Study of visitors to the proposed George Rogers
Clark Recreation Way.* D. R. McCURDY

The primary objectives of this study were to describe the user-groups and their visit to the parks and forest recreation areas along the proposed George Rogers Clark Scenic Drive and to suggest future development patterns. A total of 1,400 "usable" questionnaires were returned by groups visiting the parks and recreation areas along the proposed drive in 1969-70. Nearly all of the user-groups were families who generally visited the areas on the weekend and traveled less than 50 miles one way. Nearly two-thirds of those returning questionnaires were campers—most of whom were repeat visitors to the area. However, the most popular activity was sightseeing. Persons on annual vacations tend to favor Forest Service lake-oriented recreation areas over State Parks and Forest Service scenic areas, which receive mostly day use and have a smaller variety of recreational opportunities available. Persons using the areas as their main destination tended to travel less than 50 miles, whereas those traveling more than 50 miles used the areas as a stopping off place. Most visitors were not familiar with the proposed George Rogers Clark Scenic Drive. However, nearly 90 percent of the groups favored the proposal, mostly because it might stimulate the local economy.

SOUTHERN ILLINOIS UNIVERSITY, 67-R-023
Techniques for measuring recreation use.

D. R. McCURDY

The study resulted in the development of a model for measuring dispersed recreational use on large, contiguous areas with little or no facility development and numerous points of access. The model entailed the calculation of a ratio between the desired statistics (visits and man-hours) and vehicle counts. It was assumed that visitors arrived at the dispersed site by automobile or some other vehicle, so that if a land resource manager knew the number of occupants of each vehicle and their activities, he would have a basis to estimate use. The model now is being used to measure public use on the National Wildlife Refuge System.

IOWA STATE UNIVERSITY, 1824
Demand patterns for outdoor recreation in Iowa.

R. D. HICKMANN, W. G. BEARDSLEY, H. H.
WEBSTER, F. S. HOPKINS, and D. R. YOESTING

Interviews with 2,200 residents of Iowa were conducted in 1970 to analyze their participation in outdoor recreation. Comparisons with 1966 data showed very small upward changes in rates for most summertime activities. Driving for pleasure, bicycling, and motorcycling showed slight decreases. Most popular activities were driving for pleasure, hiking and walking, picnicking, swimming in outdoor pools, fishing, and bicycling. Snowmobiling increased from almost none in 1966 to 1.2 million days in 1970. Based on the 1966-70 projection experience, work has now begun on projections to 1980, which will have a major influence on plans for park and recreation development.

Participation in outdoor recreation by Iowans was subjected to factor analysis to determine tendencies for activities to cluster into groups. Three distinct categories emerged: hunting and fishing, power-motor related activities, and physical and sports activities. Activities within a category may be substitutable for one another in providing similar satisfaction to participants.

Analysis of change in use-patterns indicated little short-term effect from creation of a major new lake. Few respondents had changed the pattern or intensity of participation in water-based recreation. The main reason given by the few who did increase their participation was "closeness of the facilities to their homes."

UNIVERSITY OF MASSACHUSETTS, 8

*Use of aerial photographs to evaluate the recreational
resources of a river.* W. P. MacCONNELL

During the period April 1965 to September 1971, intensive study was made of land use by aerial photographs of the Connecticut River taken in 1952 and 1965. One thousand-foot strips of land on both sides of the river were classified by a land-use system devised for the project. Four hundred miles of river flowing through four States were analyzed on 1:20,000 scale photographs taken for this project in 1965.

A computer system for map information storage, manipulation, and retrieval was evolved for use with the river maps. The system accepts coded data from any type of source map or from several source maps or aerial photographs. Changes in land use between two or more time periods can be analyzed and the results portrayed in table or map form.

In a special study of urban areas on the southern section of the Connecticut River, 28 cities and town were analyzed by a new urban classification system evolved for the project. Under this system, three of 12 basic urban types were separated into three age classes, four height classes and four density classes. This study showed that the larger cities were growing rapidly in size while the population was static or even declining. The cities studied seemed to be growing like a decadent tree—they were growing vigorously at the outside edges while decaying rapidly at the core.

MICHIGAN TECHNOLOGICAL UNIVERSITY, 3016

Recreational opportunities on industrial forests in the Keweenaw Bay area, Michigan. C. R. CROWTHER

Eighteen forest land-owning companies in the Upper Peninsula of Michigan were studied with reference to five types of recreation policy: Refusal to recognize or permit recreation; disposal of recreational lands; passivity; encouragement of recreation; and pursuit of revenue through recreation. No company practices refusal; one paper company is passive. Mining companies are most active and diversified in their recreation programs. Electric power companies are next in activity, concentrating on encouragement practices. Land companies lead in revenue pursuing programs, ranking third in overall activity. Pulp and paper companies are varied in activity, tending slightly toward pursuit of revenue. Lumber and veneer companies are least active.

Factors identified as policy determinants are (in order from refusal to pursuit): Little public interest in recreation; inability of company to police its lands; company history of paternalism; concentration of ownership in large blocks; sale of products or services to local consumers; government regulation of company recreation programs; ownership of lands having special recreational value; employment of a large labor force; close relationship of recreation

lands to the company's primary operations; speculative interest in holding lands; and aggressive management. Companies influenced positively by few factors were inactive; those responsive to many factors were more active.

A study of 30 similar companies in the Lake States region showed more diversity among many of the findings. Total activities ranked as follows: Power, mining, pulp and paper, land, and lumber and veneer. No company practiced refusal; one paper company practiced passivity.

UNIVERSITY OF MINNESOTA, 19-43

Relationships between recreation land management and user satisfaction. L. C. MERRIAM, JR.

Five years of study of Minnesota parks and forests have yielded valuable data on camping and campers. The 1970 study of campers (fig. 46) and administrators of Minnesota State park and forest areas revealed that respondents might be roughly categorized by recreation area and natural area perceptions of State parks. Administrative and camper perceptions generally differed: Statistical tests of two education and nature interpretation questions implied a consensus between administrators and users on nature interpretation. The 1971 study was directed at applying the park perception categories and further testing nature interpretation as a basis for administrator-visitor consensus. State park administrators (7) and campers at St. Croix and Banning State Parks were interviewed (713 husband and wife interviews at St. Croix—a well developed



Figure 46. State park camping—Minnesota.

park, and 294 at Banning—a partly developed near-natural park). At St. Croix State Park, respondents were interviewed in three campgrounds with different development levels. Study results have been helpful to Minnesota park and planning agencies and to other researchers.

SOUTH CAROLINA—CLEMSON UNIVERSITY, 1
River stage forecasts of five canoe entry locations on the Chattooga River, North Carolina, South Carolina, and Georgia.
G. E. HOWARD

Canoeing, a forest recreation activity, has increased more than ten-fold on the Chattooga River since it was nominated as a possible National Wild River (fig. 47). The recreation facility owner, the USDA Forest Service, assumes certain responsibilities in connection with the use of the river. Many of the canoeists are novices and not familiar with optimum canoeing conditions, and certain portions of the river are extremely dangerous.

This study was undertaken to generate a river stage forecast table that would predict the stage at any canoe entry point if the stage at one point was



Figure 47. On a typical weekend, canoeists often wait in line to run rapids.

known. Hopefully, canoeists would be discouraged from attempting the river in high water. Thirty readings were taken over a 6-month period. Intercorrelations of all points provided r 's equal to or greater than 0.97.

Efforts are currently underway to install a telemetering gauge at the Highway 76 bridge. The public then would have direct access to the gauge by telephone. Information from the gauge, used in conjunction with the forecast table, provides guidance for a canoeist planning a trip on the river.

UTAH STATE UNIVERSITY, 778
The nature of urban recreation on the public forests of Utah's Wasatch front.
P. BROWN

Study results, in contrast with results of previous outdoor recreation research, show that users and nonusers of Metropolitan Weber County Pineview Reservoir do not differ significantly in income. Easy access to nearby outdoor recreation resources may serve to erase income factors suspected of limiting outdoor recreation participation for low income persons.

A significant number of Weber County urban residents proposed that the U.S. Forest Service should intensively develop more of its public lands, close to urban centers, with community-type recreation facilities. Very few residents believe the Forest Service should provide undeveloped or maximum natural setting outdoor recreation areas in these locations.

In terms of quality outdoor recreation environment, Pineview attracts persons with high incomes able to afford water-skiing and boating activities. Upper income persons, overrepresented in the boating and water-skiing activity groups, predominantly related Pineview high in quality for their recreation interest. Conversely, a significant portion of low income persons, overrepresented in the inexpensive-to-participate-in activities of picnicking, swimming, and fishing, rated Pineview low in quality for their respective recreation interests.

This study also examined the preparedness of the USDA Forest Service in dealing with law enforcement situations and responsibilities in the Intermountain

Region. All personnel in the Region (district, forest, region) with recreation and recreation area oriented-law enforcement responsibilities were sent questionnaires. In addition, all population personnel on three National forests were personally interviewed. The data reveal extreme divergences in attitudes of forest supervisors and district line personnel. Also, confusion exists at all levels regarding whether Forest Service personnel have responsibilities dealing with county, State, and Federal laws.

ADDITIONAL PROJECTS

NORTHERN ARIZONA UNIVERSITY, 6
Management of the forest recreation resource in Arizona. L. D. LOVE and A. J. SCHULTZ

UNIVERSITY OF ARIZONA, 2016-4168-014
Forest recreation demand analysis. D. A. KING

CALIFORNIA-HUMBOLDT STATE COLLEGE, 13
Optimum mix of undeveloped and developed land within a hyleopolis. G. L. PARTAIN

UNIVERSITY OF CONNECTICUT, 390
Role of the forest in open-space planning in eastern Connecticut. M. J. GRATZER and R. D. McDOWELL

UNIVERSITY OF MAINE, 5010
Recreation and forest land-use planning. J. C. WHITTAKER and T. J. CORCORAN

UNIVERSITY OF MICHIGAN, 16
Attitudes of professional foresters toward the use of forest lands for recreational purposes. B. L. DRIVER

MICHIGAN STATE UNIVERSITY, 1038
Recreational trail use and user characteristics in Michigan. L. MONCRIEF

UNIVERSITY OF MINNESOTA, 19-77
Ecomanagement of forest vegetation on parks and wilderness areas. H. L. HANSEN, E. V. BAKUZIS, and V. KURMIS

MISSISSIPPI STATE UNIVERSITY, 3-205-1121
Personality and forest recreation. H. S. BHULLAR

UNIVERSITY OF MONTANA, 210-0804

Recreation use of forest lands in Montana.

S. S. FRISSELL

UNIVERSITY OF NEVADA, 673
Recreation potential of the Truckee River Basin from Lake Tahoe to Pyramid Lake. C. S. SALADINO II

NEW YORK-CORNELL UNIVERSITY, 909
Snowmobiling impacts and resource development. F. E. WINCH, B. T. WILKINS, and G. A. HILL

NORTH CAROLINA STATE UNIVERSITY, 4032
Evolution of outdoor recreation policy among Federal land-managing agencies. L. W. MONCRIEF and J. G. KINCAID

PENNSYLVANIA STATE UNIVERSITY, 1836
Wildland recreational management. J. L. GEORGE and G. W. WOOD

PENNSYLVANIA STATE UNIVERSITY, 1842
Effects of land-use changes on the scenic qualities of Pine Creek, Pa. P. W. FLETCHER

UNIVERSITY OF TENNESSEE, 13
Characteristics of campers in forest recreation areas in Tennessee. K. F. SCHELL

TEXAS A&M UNIVERSITY, 1660
Outdoor recreation management. C. L. SHILLING and R. L. BURY

UNIVERSITY OF VERMONT, 15
Comparative economic analysis of public recreation land in forested areas of Northeast. F. O. SARGENT
UNIVERSITY OF WASHINGTON, 3
Recreational uses of forest land. G. W. SHARPE

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Industrial forest recreation policies and programs in the Lake States. The University of Michigan, Ann Arbor, Mich. 1971.

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An examination of law enforcement recognition by the United States Forest Service in the Intermountain Region. Ph.D. dissertation. Utah State University. 1972. (In process.)

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A test of differences between wilderness recreation party leaders and party members. Jour. of Leisure Res. 3(2):116-119. 1971.

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A manual for measuring public use on wildlands-Parks, forests, and wildlife refuges. 1970

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Snowmobiling over forage grasses. Proceedings of Conference On Snowmobiles and All-Terrain Vehicles, University of Western Ontario, London, Ontario. 1971.

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Impact of snowmobiling on vegetation. Proceedings of Snowmobile and Off-The-Road Vehicle Research Symposium, Michigan State University, East Lansing, Mich. 1971.

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A growing market for industrialized housing in Maine: Vacation homes. Proceedings of Industrialized Housing Symposium, School of Forest Resources, University of Maine at Orono, pp. 17-36. 1971.

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Some aspects of the residential second (vacation) home markets of Maine. M.S. thesis, University of Maine at Orono. 171 pp. 1971.

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Leisure orientation scale—replication and measurement analyses. Paper presented at Rural Sociological Society Meeting, Denver, Colo., August 1971.

MULTIPLE USE POTENTIAL OF FOREST LAND AND EVALUATION OF FORESTRY PROGRAMS

Research Problem Area 903

Most forest areas and related resources can be devoted to widely varying uses, depending on the owner's objective and the allocation of investments for resource development. On more than 300 million acres of national forests and other public lands, for example, guidelines are needed to determine the best combination of uses or systems of managing forest land for timber, water, forage, recreation, wildlife, or other purposes.

Forestry programs to increase production of timber and related forest resources need to be evaluated to determine their relative costs and effectiveness. These programs cover a wide range of activities including protection against fire, insects, and disease; reforestation; timber stand improvement; and improved timber harvesting.

LOUISIANA STATE UNIVERSITY, 1561

Landowner characteristics affecting forest management on small woodlands in Louisiana.

C. B. MARLIN

A comparison of knowledge of forestry concepts with the adoption of forest practices by small owners was made in two southern Louisiana parishes (counties). The study was designed primarily to test the relationship between the owners' understanding of basic forestry concepts and their practice of forestry.

Eighty-one small owners (20–499 forest acres) were selected at random from tax rolls and personally

interviewed. Each respondent was given two relative scores indicating (1) his level of forestry knowledge, and (2) his level of adoption of forest practices. Other variables measured were: Size of holdings; size of forest land; main use of forest; distance between home and woodlot; length of tenure; future plan for land use; occupation of owner; and owner's age, sex, income, education, and race.

Knowledge of forestry concepts appeared to be decidedly associated with the adoption of forestry practices. White owners were better informed about forestry concepts than Negro owners. Occupation was found to be significantly related to the level of adoption of forestry practices. A significant positive relationship was also found between the number of school-age children in the owner's home and his level of knowledge of forestry concepts.

The six most frequent reasons given by small owners as to why they do not practice more intensive forestry were: Lack of technical knowledge; low return on investment; forest area is too small; people do not recognize the value of growing trees; too busy; and it takes too long.

UNIVERSITY OF NEW HAMPSHIRE, 6

Forest land resources in the economy of New Hampshire.

B. B. FOSTER

The project has analyzed the State's industrial sector and the past, present, and future significance of the State's wood-fiber demand and physical supply. If New Hampshire's past industrial trends continue into the future, the fiber needs of the State's industry in 1990 may not require all the present timbered areas. Projections show that New Hampshire-based industries, while growing only slightly in absolute size, are not expanding as rapidly as the faster growing, new technology industries such as electronics, rubber, and plastic products. Nor are they declining as the leather and textile industries. The same type of analysis is now being applied to the recreation industry and to the conversion of forest land for its site and location attributes.

ADDITIONAL PROJECTS

SOUTHERN ILLINOIS UNIVERSITY, 69—R—B

A study of the trend in forest land exchange in southern Illinois.
R. M. MISCHON

INDIANA—PURDUE UNIVERSITY, 1354
Management of outdoor recreation resources.
D. M. KNUDSON

IOWA STATE UNIVERSITY, 1877
Sampling, estimation, and model building for forest resource management.
J. C. GORDON and J. C. MEADOWS

LOUISIANA STATE UNIVERSITY, 1231
Effect of State forests and parks on public recreational use of private forests in Louisiana.
R. W. McDERMID

UNIVERSITY OF MICHIGAN, 18
Informational and structural needs for multiple-use planning on public forests.
W. R. BENTLEY

MICHIGAN STATE UNIVERSITY, 1075
Computer models in the spatial analysis of natural resource economic data.
D. E. CHAPPELLE

UNIVERSITY OF NEW HAMPSHIRE, 5
Forest management control in nonindustrial woodlands.
R. R. WEYRICK

NEW JERSEY—RUTGERS STATE UNIVERSITY, 256
Evaluation of the multiple uses of New Jersey's public forest land resources.
R. F. WEST and R. ROGERS

NEW YORK—STATE COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 903—0—4
Management decision models as they relate to multiple-use forest management.
R. E. GETTY and D. A. MORRISON

OREGON STATE UNIVERSITY, F884
Objectives and management problems of owners of small forest properties in western Oregon.
C. F. SUTHERLAND

WASHINGTON STATE UNIVERSITY, 1969
Systems analysis of a forested watershed.
W. R. BUTCHER, R. A. GILKESON, and
G. A. HARRIS

UNIVERSITY OF WASHINGTON, 27
Systems analysis of the forest ecosystems of the Snohomish River Basin.
J. S. BETHEL, K. J. TURNBULL, and B. B. BARE

UNIVERSITY OF WISCONSIN, 1714
Economic analysis of alternative forest land-use allocations.
J. D. BRODIE

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Characteristics and preferences of campers at Caney Lakes Recreation area, Kisatchie National Forest. Master's thesis, Louisiana State University School of Forestry and Wildlife Management, Baton Rouge, 1971.

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An evaluation of effective multiple-use management. Master of Forestry thesis, University of Michigan, Ann Arbor. 63 pp. 1971.

IMPROVEMENT OF RURAL COMMUNITY INSTITUTIONS AND SERVICES

Research Problem Area 908

This research supplements that on improving income opportunities in rural communities. It will help identify the ways by which rural communities can develop the organizations, agencies, services, and leadership needed to make them attractive places to live, work, and establish businesses.

Some rural communities are greatly in need of research information to help in adjusting to sharp increases or decreases in population. Modern transportation and communication have contributed to the development of trading and social centers serving large geographic areas, and have caused the

decline or elimination of a great many small centers. Uncoordinated development and other changes in land use, with no reference to any overall plan, often make it impossible to provide public services economically. These are among the reasons why rural communities encounter severe difficulties in meeting the changing needs of people at a cost they can afford.

MICHIGAN STATE UNIVERSITY, 1052
Planning procedures for public forests.

R. J. MARTY

Project planning identified a need for improved guides to economic evaluations of management alternatives on public forests, suitable for self-use by persons inexperienced in this activity. To fill this need, a manuscript is being prepared on benefit-cost analysis.

ADDITIONAL PROJECTS

LOUISIANA TECH UNIVERSITY, 6
Workmen's compensation and safety in timber harvesting and wood-using mills, Arkansas and Louisiana.
J. E. CAROTHERS

PUBLICATIONS

CAROTHERS, J. EDWIN.
Workmen's compensation and safety. Presented at Annual Safety Workshop, Southern Forest Products Association, Jackson, Miss., February 5, 1971.

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What you should know about workmen's compensation. Pulpwood Production and Sawmill Logging. May, June, July 1971.

Appendix I

INDEX OF PROJECTS BY STATES

<i>State</i>	<i>RPA</i>	<i>Proj. No.</i>	<i>Abbreviated Title</i>	<i>Project Leader</i>	<i>Page</i>
Alabama	111a	904	Woody Plants and Phytocides	M. C. Carter	23
Auburn Univ.	113	909	Forest Condition Classes	E. W. Johnson	82
	401	910	Plastic-Overlaid Plywood	E. J. Biblis	102
	301	912	Forest Trees Genetics	J. F. Goggans	28
	111a	913	Fertilization of Loblolly Pine	M. C. Carter	23
	401	914	Figured and Unfigured Wood	H. O. Beals	102
	202	911	Hypoxylon in Southern Hardwoods	T. C. Davis	68
Alaska Univ. of	111a	270-0541	Succession on Puland Sites	B. L. Neiland	23
	101	270-0504	Alaska Forest Types Nutrient Cycles	K. VanCleve	3
	101	270-0545	North Facing Slopes	B. J. Neiland	4
	401	270-7503	Logging Costs Interior Forests	R. Snyder	90
Arizona Univ. of	920	14	Recreation Demand	D. A. King	115
	102	19	Forest and Range Ecosystems	J. O. Klemmedson	6
	110	22	Volume Tables: Ponderosa Pine	G. S. Lehman	78
	301	25	Christmas Tree Production	R. F. Wagle	36
	107	17	Snow Water Yield from Forests	D. B. Thorud	10
Northern Arizona Univ.	111c	1	Stand Density Measures	C. O. Minor	81
	401	2	Wood Quality and Growth	G. Voorhies	102
	110	3	Vegetation and Climates	D. W. Berry	78
	112	5	Range Forage on Parks	L. D. Love	56
	902	6	Forest Recreation Resources	L. D. Love	115
	113	7	Aerial Surveys of Resources	T. E. Avery	82
Arkansas Univ. of	102	610	Use Alternatives on Forests	H. A. Holt	6
	201	611	Pine Sawflies	L. O. Warren	61
	201	656	Bark Beetles and Fungi	W. C. Yearian	65
	201	662	Pine Seed Production, Insect Control	W. C. Yearian	65
	202	663	Forest-Tree Diseases	F. H. Tainter	72
	202	741	Forest Area Viruses	J. P. Fulton	72
	111a	749	Forest Tree Establishment	H. P. Holt	23

<i>State</i>	<i>RPA</i>	<i>Proj. No.</i>	<i>Abbreviated Title</i>	<i>Project Leader</i>	<i>Page</i>
California	301	11	Provenance; Coast Redwood	J. H. Hansen	36
Humboldt	111b	12	Regeneration of Redwood	E. W. Pierson	46
State	902	13	Undeveloped and Developed land	G. L. Partain	115
College	111c	16	Thinning Test of Douglas-Fir	E. W. Pierson	80
	110	17	Vegetation Habitat Types	D. Thornburgh	75
	111b	18	Lupine, Planted Redwood	D. Thornburgh	51
	111b	20	Acceptable Stocking Levels	D. L. Adams	46
	111c	21	Fertilizer, Redwood, Douglas-Fir	D. Thornburgh	81
	111b	23	Commercial Thinning, Redwood	R. A. Hursey	51
	401	24	Diameter Shrinkage, Logs	R. A. Hursey	102
	110	25	Total Bole, Bark Volumes	D. L. Adams	76
	111a	26	Redwood Tissue Calorific Values	R. A. Hursey	23
California	111a	2179	Ecological Potential, Redwood	E. C. Stone	23
Univ. of	113	2180	Multiband Spectral Reconnaissance	R. N. Colwell	82
	401	2181	Wood Machining Process	F. E. Dickinson	102
	202	2348	Microbiology and Pathology, Wetwood	W. W. Wilcox	72
	303	2349	Optimum Forest Production	D. E. Teeguarden	84
	110	2350	Long-Range Timber Supply	H. J. Vaux	78
	512	2357	Marketability of Wood Products	F. E. Dickinson	108
	202	2383	Fomes Annosus Root Rot	F. W. Cobb	68
	303	2447	Thinning Regimes for Conifers	R. F. Grah	84
	401	2495	Utilization of Bark	A. B. Anderson	90
	112	2500	Range Plant Population	H. F. Heady	56
	513	2505	Markets for Public Timber	H. J. Vaux	88
	110	2520	Simulation of Forest Stands	L. C. Wensel	78
	502	2538	Wood Procurement Systems	W. L. McKillop	87
	401	2553	Heating Methods in Wood	D. Arganbright	102
	107	2751	Urbanization and Natural Ecosystems	J. R. McBride	8
Colorado	301	319	Patterns in Spruce Crossability	G. H. Fechner	36
State	401	320	Particleboard Binders	H. E. Troxell	90
Univ.	107	321	Forest Cover, Water Yields	E. W. Mogren	10
	401	322	Properties of Lodgepole Pine	D. L. Crews	102
	110	323	Timber Supply Forecasting	W. E. Frayer	76
	110	324	Resource Systems Classification	C. D. Bonham	78
	110	328	Multiple-Use Resource Model	H. W. Steinhoff	78
Connecticut	904	340	White-Tailed Deer Productivity	R. D. McDowell	39
Univ. of	904	376	Habitat of Cottontails	R. D. McDowell	43
	902	390	Open-Space Planning, Forests	M. J. Gratzner	115
Connecticut	109	403	Simulators of Environmental Effects	P. E. Waggoner	12
New Haven	107	408	Conserving Soil Moisture, Stomata Control	P. E. Waggoner	8
	101	411	Phosphorus in Lake Sediments	C. R. Frink	4
	110	414	Multivariate Analysis, Hardwood Data	P. E. Waggoner	76
	107	415	Waste Water Renovation	D. E. Hill	8
	905	416	Attenuation of Noise, Vegetation	D. E. Aylor	58

<i>State</i>	<i>RPA</i>	<i>Proj. No.</i>	<i>Abbreviated Title</i>	<i>Project Leader</i>	<i>Page</i>
Delaware	111b	759	Nutrition of Holly	C. W. Dunham	47
Univ. of	104	715-E	Wild-Land Ecology	R. Jones	111
Florida	111a	1130	Soil Survey Information	W. L. Pritchett	13
Univ. of	102	1250	Water Control; Forest Production	C. M. Kaufman	6
	301	1344	Improvement of Sand Pine	R. K. Strickland	29
	111a	1534	Fertilization of Southern Pine	W. L. Pritchett	23
	301	1293	Stock-Scion, Southern Pine	W. H. Smith	29
Georgia	111a	14	Biosynthesis of Oleoresins	C. L. Brown	23
Univ. of	401	15	Exterior Particleboard	J. T. Rice	102
	111b	17	Growth and Wood Formation	J. R. Beckwith	51
	201	18	Insects; Pine Cones and Seeds	R. T. Franklin	65
	303	19	Cash Flow and Forest Management	J. L. Clutter	83
	904	20	Contaminants in Animals	J. H. Jenkins	43
	110	21	Growth and Yield of Loblolly	J. L. Clutter	76
	111b	22	Quick-Coppicing Hardwoods	J. T. May	51
Hawaii	111a	674	Tropical Forest Communities	N. P. Kefford	13
Univ. of	202	721	Antagonism in Forest Soil	W. Ko	72
Idaho	110	1	Woodland-Shrub Grazing Land Site	E. W. Tisdale	78
Univ. of	111a	2	Coniferous Seedling Root Growth	H. Loewenstein	23
	301	3	Heritability, Population of Ponderosa Pine	C. W. Wang	36
	112	12	Livestock Tramping, Forage Productivity	L. A. Sharp	56
	201	13	Cone and Seed Insects	J. A. Schenk	66
	111a	14	Ecology of Red Alder	F. D. Johnson	14
	401	15	Precision Thin Sawing	K. Sowles	102
	111a	16	Fertilization: Douglas and Grand Fir	H. Loewenstein	23
	201	17	Stand Character, <i>S. ventralis</i> Populations	J. A. Schenk	62
	112	18	Browse Species, Prescribed Burning	K. E. Hungerford	56
	111b	19	Pocket Gopher Tree Damage	K. E. Hungerford	51
	202	11	Timber Tree Decay	A. D. Partridge	72
Illinois	102	308	Soil Microbiology	R. F. Fisher	6
Univ. of	101	311	Soil-Site Relationships	H. W. Fox	5
	401	334	Penta-Treatment and Strength	C. S. Walters	102
	401	336	High Pressure Treatment, Oak	C. S. Walters	102
	111a	360	Moisture Stress; Growth Wood	A. R. Gilmore	24
Illinois	110	4-67	Dendrochronology, Shortleaf Pine	W. C. Ashby	76
Southern	904	7-67	White-Tailed Deer Dispersal	W. D. Kimstra	43
Illinois Univ.	111a	64-R-4	Hardwood Planting, Old Fields	C. A. Budelsky	14
	111b	67-R-14	Native Trees for Parks	D. R. McCurdy	47
	902	67-R-23	Measuring Recreation Use	D. R. McCurdy	112

<i>State</i>	<i>RPA</i>	<i>Proj. No.</i>	<i>Abbreviated Title</i>	<i>Project Leader</i>	<i>Page</i>
Illinois	301	69-B-1	Graft Incompatibility in Juglans	M. Kaeiser	36
Southern .	401	69-R-A	Particleboard, Roughness	A. A. Moslemi	91
Illinois University	903	69-R-B	Forest Land Exchange	R. M. Mischon	117
	301	69-R-11	Genotypic Variation	P. L. Roth	29
	902	69-R-18	Visitors to National Forests	D. R. McCurdy	112
	401	70-R-5	Fiber-tracheid Characteristics, Ailanthus	A. A. Moslemi	102
	904	1-70	Fawn Mortality	R. E. Hawkins	43
	401	69-23	Fiberboard Strength Properties	A. A. Moslemi	92
	111a	71-R-3	Sulfur Dioxide, Tree Seedlings	C. A. Budelsky	24
	301	70-R-21	Soil Temperature, Walnut Growth	J. S. Fralish	36
	502	70-R-11	Wood Color, Demand for Walnut	R. S. Ferell	86
	301	70-R-25	Apical Dominance, Walnut	P. L. Roth	36
	301	70-R-26	Walnut Cold Hardiness	P. L. Roth	36
Indiana	801	1353	Design of Wood Rafters	S. K. Suddarth	108
Purdue	903	1354	Outdoor Recreation Resources		
Univ.			Management	D. M. Knudson	118
	401	1355	Behavior of Wood-Base Composite	M. O. Hunt	92
	111a	1476	Culture of Hardwoods	W. R. Byrnes	24
	111a	1477	Forest Ecosystems Ordination	C. Merritt	24
	110	1586	Forestry Data Processing System	C. C. Meyers	78
Iowa	902	1824	Demand Patterns, Recreation	H. H. Webster	112
State	301	1872	Wood Fiber Yield, Physiological		
Univ.			Analysis	J. C. Gordon	36
	903	1877	Forest Resources Management Models	J. C. Gordon	118
Kansas	111b	721	Strip-Mined Land Planting	W. A. Geyer	51
State	111a	770	Rapid Fiber Production	W. A. Geyer	24
Univ.	301	771	Forest Tree Improvement	R. W. Funsch	36
Kentucky	102	199	Forest Soil Properties	R. L. Blevins	5
Univ. of	512	601	Log Breakdown	D. B. Richards	108
	401	602'	Glued Wood Corner Joints	D. B. Richards	102
	801	1015	Appalachian Lumber Use	O. M. Davenport	108
	401	1028	Wood Fiber Mechanics	R. C. Tang	102
	401	1029	Composite Pole Laminates	R. C. Tang	102
	107	603	Forested Watershed Ecosystems	E. H. White	10
	111a	604	Hardwood Genetics, Physiology	S. B. Carpenter	24
Louisiana	111c	1	Forestry Yield Data	L. P. Blackwell	81
Tech Univ.	401	3	Bark Soil Conditioner	D. L. Fitzgerald	102
	202	5	Pine-Oak Gall Rusts	F. F. Jewell	69
	908	6	Workmen's Compensation	J. E. Carothers	119
	214	7	Environmental Contaminants	H. E. Garrett	89
	111b	4	Site Index	J. Kuprionis	48
	202	22	Controlled Burning	J. Murad	69

<i>State</i>	<i>RPA</i>	<i>Proj. No.</i>	<i>Abbreviated Title</i>	<i>Project Leader</i>	<i>Page</i>
Louisiana	202	51	Cronratium Fusiforme	J. White	69
Tech Univ.	202	52	Fusiform Rust Morphology	F. F. Jewell	69
	303	61	Workmen's Safety	J. E. Carothers	84
Louisiana	903	1231	Public Recreational Use	R. W. McDermid	118
State	111b	1237	Producing Christmas Tree	C. W. Brewer	47
Univ.	111b	1266	Competition, Pine Plantations	R. D. Keister	51
	102	1276	Rooting Pine Trees	N. E. Linnartz	6
	401	1440	Liquid and Gas Permeability	R. W. McDermid	102
	302	1444	Timber Harvesting Systems	R. W. McDermid	59
	401	1477	Southern Pine Veneer Drying	W. E. Loos	102
	111b	1500	Regenerating Southern Pine	B. H. Box	51
	904	1510	Population of Woodcock	F. W. Martin	43
	904	1525	Distribution and Population; Wood Duck	F. W. Martin	43
	111a	1538	Even-aged Loblolly Pine	E. T. Choong	24
	904	1551	Browse Availability	R. E. Noble	43
	111b	1547	Herbicide Pine Thinning	T. D. Keister	51
	903	1561	Small Woodland Management	C. B. Martin	117
Maine	111a	5002	Growth of Forest Trees	C. E. Schomaker	24
Univ. of	401	5004	Wood Properties and Grades	J. E. Schomaker	102
	904	5005	Deer Upon Vegetation	S. D. Schemnitz	43
	111a	5006	Tree Utilization	H. E. Young	24
	201	5007	Control of Gall Midge	E. A. Osgood	66
	102	5008	Fertilization of Spruce	C. E. Schomaker	6
	401	5009	Properties of Maine Woods	N. P. Kutscha	93
	902	5010	Recreation and Forest Land Use	J. C. Whittaker	115
	301	5011	Soil-Tree Relationships	R. A. Struchtemeyer	36
	201	5013	Hardwood Defoliators	D. E. Leonard	62
Maryland	201	H-083	Pine Cone Insects	W. E. Bickley	66
Univ. of	201	H-101	Forest Insects	A. L. Steinhauer	66
	202	J-101	Seedlings, Soil Fungi	W. L. Klarman	72
	301	L-100	Vegetative Propagation Pines	J. B. Shanks	36
Massachusetts	202	1	Maple Tree Decline	W. M. Banfield	70
Univ. of	107	2	Evapo-Transpiration, Drainage	D. L. Mader	11
	401	3	Rheology of Wood	R. B. Hoadley	102
	401	4	Wood Properties	H. B. Gatslick	102
	904	5	Requirements of Grouse	R. B. Brander	40
	902	8	Recreational Resources	W. P. MacConnell	112
	111a	9	Maple Tree Roots	B. F. Wilson	14
	111a	10	Cambial Activity of Trees	B. F. Wilson	24
	302	11	Volume Growth	J. C. Mawson	59
	904	12	Man-Animal Interactions	J. S. Larson	43
	113	13	Change in Human Environment	W. P. MacConnell	82

<i>State</i>	<i>RPA</i>	<i>Proj. No.</i>	<i>Abbreviated Title</i>	<i>Project Leader</i>	<i>Page</i>
Michigan Univ. of	111a	8	Biosystematics of Birch	B. V. Barnes	24
	111a	12	Angiosperm Vessel Length	R. Zahner	16
	201	14	Aspen Beetle Population	F. B. Knight	66
	202	15	Treated Wood Microorganisms	H. L. Morton	70
	902	16	Foresters View, Forest Recreation	B. L. Driver	115
	110	17	Sequential Sampling Tree Characteristics	G. W. Fowler	77
	903	18	Multiple Use Planning Information	W. R. Bentley	118
	202	19	Air Pollution-Tree Diseases	H. L. Morton	72
	401	20	Site Quality-Wood Quality	R. Zahner	103
Michigan State Univ.	301	936	Mineral Nutrition; Trees	J. W. Hanover	30
	201	942	Arthropod Component; Conifers	J. A. Butcher	66
	303	978	Forest Management Opportunities	V. J. Rudolph	84
	111a	979	Tree Seedling Nutrition	G. Schneider	24
	401	980	Utilization and Marketing	O. Suchsland	103
	904	982	Wildlife Food; Aesthetic Value	L. W. Gysel	43
	111b	984	High Quality Black Walnut	D. P. White	51
	902	1038	Recreational Trail Use	L. Moncrief	115
	401	1048	Dimensional Changes of Wood	O. Suchsland	93
	202	1049	Decay and Termite Resistance	E. A. Behr	72
	908	1052	Public Forests	R. J. Marty	119
	301	1061	Forest Tree Improvement	J. W. Wright	36
	903	1075	Resource Economics Models	D. E. Chappelle	118
Michigan Technological Univ.	110	3012	Data Processing, Forest Measurement	W. Meter	77
	902	3016	Industrial Forest Recreation	C. R. Crowther	113
	202	3028	Sugar Maple Borer Injury	G. A. Hesterberg	72
	111b	3110	Northern Hardwoods Cutting Methods	V. W. Johnson	48
	111c	3117	Forecasting Value Growth, Hardwood	W. R. Wynd	80
	401	3118	Transport Trailer Deck	G. A. Hesterberg	103
	201	3119	Pine Bark Aphid Control	N. F. Sloan	66
	901	3210	Pulp Residual Hemicelluloses	B. C. Sun	109
	302	3310	Pulpwood Skidding	H. M. Steinhilb	59
	111c	3311	Tarif Tables for Aspen	V. W. Johnson	81
Minnesota Univ. of	111a	3312	Edaphic Soil Properties, Tree Growth	S. G. Shetron	16
	904	17-85	Small Mammals; Reseeding	J. R. Beer	43
	111a	19-16	Red Pine Reproduction	B. A. Brown	16
	111b	19-18	Tubelings for Regeneration	B. A. Brown	52
	111b	19-19	Hazel Understories	J. C. Tappeiner	49
	902	19-43	Recreation; Land Management	L. C. Merriam	113
	111c	19-45	Forest Stand Dynamics	D. J. Gerrard	81
	401	19-56	Freezing for Drying	R. W. Erickson	103
	401	19-62	Long-Term Behavior; Particle-Board	J. G. Haygreen	103
	401	19-60	Acceptance of Aspen Studs	R. D. Thompson	103
	902	19-77	Management of State Parks	H. L. Hansen	115
	301	19-78	Hybridization Studies	C. A. Mohn	36

<i>State</i>	<i>RPA</i>	<i>Proj. No.</i>	<i>Abbreviated Title</i>	<i>Project Leader</i>	<i>Page</i>
Minnesota	202	19-79	Ecological Forest Production	E. V. Bakuzis	72
Univ. of	202	22-18	Dwarf Mistletoe	D. W. French	72
Mississippi	201	1029	Economic Insects; Forest Seedlings	W. W. Neel	66
State	902	1121	Personality and Forest, Recreation	H. S. Bhullar	115
Univ.	111a	1122	Multinodal Growth Shoot Systems	W. W. Elam	24
	111a	1128	Nutrient Cycle in Pines	G. L. Switzer	24
	502	1130	Accounting for Timber Harvesting	R. R. Foil	87
	401	3622	Southern Pine Pole Preservation	W. S. Thompson	94
	401	3623	Wood Properties of Hardwood	F. W. Taylor	95
	401	3624	Efficiency: Manufacture	W. S. Thompson	103
	401	3625	Wood Adhesives	H. R. Rogers	96
	401	3636	Laminated Hardwood Lumber	J. Yao	103
	401	3628	Variables of Poles and Piling	W. C. Kelso	103
	904	3422	Stand Conversion; Wildlife Populations	G. A. Hurst	40
Missouri	201	149	Forest and Plantation Communities	W. H. Kearby	66
Univ. of	111a	160	Tree Seedling Morphology	G. N. Brown	24
	111a	162	Hardwood Forest Ecology	G. S. Cox	24
	107	163	Forest Hydrology	C. D. Settergren	9
	301	164	Genetic Investigations	R. B. Polk	30
	401	165	Anatomy and Properties; Woods	E. A. McGinnes	103
	303	166	Wood Industries	K. T. Adair	84
	110	167	Missouri Forest Conditions	A. J. Nash	78
	303	168	Timber Production Opportunities	R. C. Smith	84
Montana	502	202	Marketing Montana Lumber	R. F. Wambach	87
Univ. of	112	603	Grazing Use; Forage Yield	M. S. Morris	55
	902	804	Recreation on Forest Lands	S. S. Frissell	115
	301	904	Hybridization of Larch	G. M. Blake	31
	111a	1001	Soil Moisture; Forest Communities	T. J. Nimlos	17
	110	3001	Ecosystem study; Elk Creek Drainage	L. K. Forcier	79
	904	3002	Impact Logging; Sapphire Range	R. R. Ream	43
	214	3004	Hydrogen Flouride; Coniferous Species	C. C. Gordon	89
	401	3003	Chemistry, Distribution and Biosynthesis	F. Shafizadeh	103
	111a	1801	Nutrient Culture of Larch	M. J. Behan	17
Nebraska	905	20-23	Windbreak Shelter Effects	W. T. Bagley	57
Univ. of	905	20-28	Tree Breeding	W. T. Bagley	58
Nevada	902	673	Recreational Potential	C. S. Saladino	115
Univ. of	111a	674	Erosion-Control Planting	E. L. Miller	24
	107	675	Water Retention and Movement in Snowpacks	C. M. Skau	11
	111a	676	Jeffrey Pine Regeneration	C. M. Skau	17

<i>State</i>	<i>RPA</i>	<i>Proj. No.</i>	<i>Abbreviated Title</i>	<i>Project Leader</i>	<i>Page</i>
New Hampshire	401	3	Stress-Strain; Hardwoods	J. L. Hill	96
Univ. of	201	4	Ecology of Acarina	R. M. Reeves	66
	903	5	Forest Management	R. R. Weyrick	118
	903	6	Forest Land Resources	B. B. Foster	117
	303	7	Timber Stand Improvement	P. E. Bruns	84
	904	8	Energy Requirement, Deer	W. W. Mautz	44
New Jersey	111a	245	Phase Change in Plants	C. E. Hess	24
Rutgers	111a	254	Allometric Relation in Trees	B. B. Stout	17
Univ.	903	256	Public Forest Land Resources	R. F. West	118
	201	425	Low Host Density	F. C. Swith	63
	201	436	Metabolism of Insecticides	A. J. Forgash	63
	905	257	Environmental Stress	B. B. Stout	58
New Mexico	904	2	Mule Deer Population	V. W. Howard	41
State Univ.	111a	5	Soil-Site Requirements	A. G. Wollum	24
	201	7	Ponderosa Pine Cone Beetle	H. G. Kinzer	66
	513	8	Market Opportunities	J. R. Gray	88
	111a	10	Fertilization, Deer Browse	V. W. Howard	24
New York	102	901	Ectotropic Mycorrhizae	E. L. Stone	6
Cornell	111a	905	Soil Fertility	E. L. Stone	18
Univ.	113	906	Rural Land Classification	L. S. Hamilton	82
	904	907	Vegetation for Wildlife	J. W. Caslick	42
	902	909	Snowmobiling Impact	F. E. Winch	115
New York	401	102-0-1	Fertilization and Wood Properties	Carl DeZeeuw	96
Syracuse	107	107-0-6	Watershed Model Studies	P. Black	10
College of	110	110-0-8	Inventory of Forest Resources	C. A. Bickford	79
Forestry	111a	111-2-3	Seed Dormancy	E. Sondheimer	24
	111a	111-2-6	Tree Growth Studies	A. B. Tepper	24
	111c	111-5-5	Growth, Allowable Cut	T. Cunia	81
	301	301-1-2	Genetic Improvement; Hardwoods	W. T. Gladstone	31
	401	401-4-2	Xylem Ray Cells in Conifers	T. E. Timell	96
	903	903-0-4	Decision Models	R. E. Getty	118
	904	904-1-5	Deer Habitat Studies	D. F. Behrend	44
	904	904-3-1	Aquatic Plants	R. T. LaLonde	44
	901	901-0-3	Fertilization Water Quality	A. L. Leaf	109
	401	401-3-12	Treated Wood Analysis	J. A. Meyer	103
North Carolina	301	4002	Wood Property Variation	R. C. Kellison	36
State Univ.	401	4005	Wood Fiber Properties	A. C. Barefoot	103
	401	4008	Paper and Paperboard	C. G. Landes	97
	301	4010	Genetic Superiority	T. O. Perry	36
	202	4012	Diseases and Wood Deterioration	L. F. Grand	72
	110	4014	Non-Linear Models; Growth	W. L. Hafley	77
	301	4015	Yellow-Poplar Variation	R. C. Kellison	32

<i>State</i>	<i>RPA</i>	<i>Proj. No.</i>	<i>Abbreviated Title</i>	<i>Project Leader</i>	<i>Page</i>
North Carolina State Univ.	401	4029	Cellulaze Lignin	H. Chang	103
	301	4016	Taxonomic Relationships	L. C. Saylor	32
	111b	4018	Seed Orchard, Fertilization, Irrigation	C. B. Davey	52
	502	4022	Wood Residue Production	D. H. Steensen	87
	301	4023	Variation of White Oak	J. W. Hardin	36
	901	4025	Pulp Industry Pollution	H. Chang	109
	904	4026	Forest Wildlife Studies	F. S. Barkalow	44
	401	4027	Fracture Model for Wood	R. G. Pearson	103
	901	4028	Water Reuse in Pulp	C. N. Rogers	109
	111b	4030	Growth of Pines, Wetlands	T. E. Maki	52
	905	4031	Urban Forest Space	J. C. Lammi	58
	902	4032	Outdoor Recreation Policy	L. W. Moncrief	115
	303	4033	Hardwood Production	D. L. Holley	83
	401	4024	Lignin Modification	K. P. Kringstad	97
North Dakota State Univ.	905	12-1	Shelter Belts	E. P. Lana	57
Ohio, OARDC Wooster	111b	1	Fertilizer Effects, Maple, Poplar	J. P. Vimmerstedt	52
	301	2	White Pine Seed Development	H. B. Kriebel	36
	201	3	Control of Insects, Pine	D. G. Nielsen	64
	111a	5	Juvenile Growth, Red Oak	A. R. Vogt	24
	111a	6	Physiology of Wood	F. W. Whitmore	24
	301	7	Physiological Genetics	B. A. Thielges	36
	202	8	Plantation Tree Disease	C. Leben	72
	301	9	Tree Breeding	B. A. Thielges	36
	111b	10	Christmas Tree Production	J. H. Brown	52
Oklahoma State Univ.	112	1161	Artificial Regeneration, Short-leaf Pine	T. H. Silker	55
	201	1235	Pine Tip Moth	R. D. Eikenbary	64
	301	1241	Shortleaf Pine	R. W. Stonecypher	37
	301	1304	Loblolly and Shortleaf Pine	R. W. Stonecypher	37
	111a	1332	Herbicides in Woody Plants	E. Basler	24
	301	1348	Evaluation of Pine Hybrids	R. W. Stonecypher	37
	301	1349	Cottonwood Improvement	R. W. Stonecypher	37
	111b	1360	Undesirable Woody Plants	T. H. Silker	49
	904	1442	Game and Timber Production	J. L. Teate	42
	111c	1476	Forest Sampling	N. Walker	81
Oregon State Univ.	111a	646	Forest Land Management	R. H. Waring	18
	301	759	Variations of Douglas-Fir	M. H. Irgens	33
	301	760	Development of Douglas-Fir Seed	W. P. Wheeler	33
	111a	761	Mechanisms of Succession	M. Newton	19
	301	762	Juvenile Douglas-Fir Flowering	K. K. Ching	33
	111a	794	Douglas-Fir seedlings, Transpiration	W. K. Ferrell	25
	401	812	Properties of Wood	R. T. Lin	103
	202	819	Phytophthora Root Rot	L. F. Roth	70
	401	825	Factors on Pulping	W. J. Bublitz	103

<i>State</i>	<i>RPA</i>	<i>Proj. No.</i>	<i>Abbreviated Title</i>	<i>Project Leader</i>	<i>Page</i>
Oregon State Univ.	303	833	Chemical Brush Control	C. F. Sutherland	84
	110	843	Douglas-Fir Growth Prediction	D. P. Paine	78
	401	763	Hemlock, Permeable and Refractory	R. L. Krahmer	97
	201	868	Seed and Cone Insect Pests	W. P. Nagel	66
	903	884	Small Forest Management	C. F. Sutherland	118
	302	870	Harvesting Residue	H. A. Froehlich	59
	111a	880	Douglas-Fir Growth Models	R. H. Waring	25
	111a	881	Floral Initiation, Douglas-Fir	D. P. Lavender	25
	111a	882	Herbicides Impact	M. Newton	19
	110	883	PPS Sampling	D. P. Paine	79
Pennsylvania State Univ.	107	1495	Timber Harvesting Methods	W. E. Sopper	11
	401	1625	Forest Products Industries	P. C. Kersavage	103
	202	1702	Forest Tree Diseases	F. A. Wood	72
	102	1745	Revegetation: Coal Mining	R. J. Hutnik	6
	201	1750	Gall Aphid: Control	E. A. Cameron	66
	111c	1805	Stochastic Models; Simulation	P. E. Dress	81
	111b	1816	Wood Fiber Production	T. W. Bowersox	49
	401	1823	Rheology of Wood	W. K. Murphey	97
	202	1825	Canker of Maple	W. W. Ward	72
	902	1836	Recreational Management	J. L. George	115
	902	1842	Land Use Changes	P. W. Fletcher	115
	401	1869	Adhesive and Wood Fibers	F. C. Beall	103
Rhode Island Univ. of	904	953	Forest Alteration, Deer Movement	J. Kupa	44
	105	954	Evapotranspiration Related to Site	J. Brown	7
	904	955	Wildlife Telemetry	E. F. Patric	44
South Carolina Clemson Univ.	902	1	River Stage Forecasts	G. E. Howard	114
	111a	2	Irrigation Upland Hardwoods	T. E. Wooten	25
	111c	4	Aerial Photos, Forest Management	W. A. Shain	81
	301	704	Genetics of Trees	R. E. Schoenike	33
	301	705	Inbreeding of Pine	R. E. Schoenike	37
	111b	706	Harvest; Maximize Returns	J. R. Warner	52
	303	707	Logging Costs	W. A. Shain	84
	301	717	Tree Improvement Studies	R. E. Schoenike	37
	111b	789	Irrigation and Fertilization	N. B. Goebel	52
	111a	853	Gas Exchange; Pine Needles	R. M. Allen	25
	301	881	Variation and Inheritance, Longleaf Pine	R. E. Schoenike	37
	111a	887	Pine Flower Phenolics	R. M. Allen	19
	401	888	Appalachian Hardwoods Permeability	T. E. Woods	103
	201	905	Pine Reproduction Weevils	R. C. Fox	66
	401	925	Wood Properties of Trees	T. E. Wooten	103
South Dakota State Univ.	905	475	Selection and Propagation	D. E. Herman	58
	110	556	Successional Changes	D. R. Progulske	79
	112	561	Tree Encroachment	F. R. Gartner	54

<i>State</i>	<i>RPA</i>	<i>Proj. No.</i>	<i>Abbreviated Title</i>	<i>Project Leader</i>	<i>Page</i>
Tennessee Univ. of	111b	2	Fertilizers and Irrigation	E. R. Buckner	52
	904	3	Quail Management	R. W. Dimmick	44
	904	6	Wood Duck Ecology	R. W. Dimmick	42
	202	7	Blight; American Chestnut	E. Thor	73
	301	8	Christmas Tree Breeding	E. Thor	37
	401	9	Hardwood Characteristics	H. A. Core	103
	303	10	Timber-Growing Practices	G. R. Wells	84
	904	11	Physiological Response; Wildlife	M. R. Pelton	44
	904	12	Ecology and Behavior; Bears	M. R. Pelton	44
	902	13	Forest Recreation Campers	K. F. Schell	115
	111b	14	Seedling Root Deformation	F. W. Woods	52
	202	15	Mycorrhizae Control of Fungi	F. W. Woods	71
Texas A&M Univ.	502	1524	Distribution of Wood Products	H. B. Sorenson	86
	201	1525	Southern Pine Beetle	T. L. Payne	65
	202	1526	Live Oak Decline	E. P. Van Arsdel	73
	401	1650	The Formosan Termite	A. E. Lund	103
	902	1660	Recreation Management	R. L. Bury	115
	111b	1673	Culture of Hardwoods	R. G. Merrifield	52
	110	1761	Pine Plantation Growth	D. M. Moehring	79
	401	1733	Southern Pine Bark Utilization	D. F. Durso	104
	301	1826	Woody Plant Cells	D. F. Durso	37
	111a	1527	Loblolly Pine Requirements	R. R. Rhodes	20
	111a	1649	Water Stress Loblolly Pine	D. M. Moehring	25
Stephen F. Austin State Univ.	110	1	Unthinned Loblolly Yields	J. D. Lenhart	79
	301	2	"Lost Pines" Root Growth	M. V. Bilan	34
	301	3	Southern Pine Hybridity	R. R. Hicks	35
	111a	4	Foliage Morphology "Lost Pines"	M. V. Bilan	25
	901	5	Pulp Effluent Land Disposal	L. G. Watterston	109
	111c	6	Loblolly Tree Weight Volume	J. D. Lenhart	81
	110	7	Southern Pine Tarif Tables	H. V. Wiant	78
	901	8	Prescribed Burning, Air Pollution	H. C. Reeves	109
	301	9	River Birch Silage Cellulose	R. R. Hicks	37
	201	11	Ips Bark Beetle Behavior	J. E. Coster	66
	301	12	Loblolly x Shortleaf Frequency	R. R. Hicks	37
Utah State Univ.	112	670	Foliage Removal Effects	G. B. Coltharp	56
	110	757	Conifer Distribution	R. M. Lanner	79
	107	777	Intermountain Stands; Water Balance	G. E. Hart	11
	902	778	Urban Recreation, Forests	P. Brown	114
	107	780	Root Distribution, Soil Moisture	J. D. Schultz	11
	111c	806	Biomass and Productivity Measurements	T. W. Daniel	81
Vermont Univ. of	111b	1	Christmas Tree Culture	M. L. McCormack	52
	111b	2	Leader Damage, Growth, Conifers	T. L. Turner	50
	110	4	Volume Equations	C. C. Myers	78

<i>State</i>	<i>RPA</i>	<i>Proj. No.</i>	<i>Abbreviated Title</i>	<i>Project Leader</i>	<i>Page</i>
Vermont	904	7	Wood Duck Population	R. M. Fuller	44
Univ. of	111b	8	Wood Quality of Birch	P. R. Hannah	52
	111b	10	Chemical Weed Suppression	T. R. Flanagan	50
	111a	11	Sap Flow in Sugar Maples	J. W. Marvin	25
	111a	12	Cell Transitions; Hardwoods	F. M. Laing	25
	303	14	Management by Programming	F. H. Armstrong	84
	902	15	Public, Recreation Land	F. O. Sargent	115
	302	16	Maple Sap Vacuum System	F. M. Laing	60
	111a	18	Maple Tissue Cultures	M. Morselli	20
	904	19	Deer Carrying Capacity	T. W. Hoekstra	44
Virginia	513	636118	Forest Regulation Model	E. F. Thompson	87
Polytechnic	401	636119	Accelerated Wood Drying	R. E. Martin	98
Institute	904	636121	Oak Hickory Stands Browse	B. S. McGinnes	44
	904	636124	White Tailed Deer Nutrients	R. L. Kirkpatrick	43
	111a	636125	Ribosomal System	R. E. Adams	21
	111b	636134	Models of Forest Stands	H. A. I. Madgwick	52
	904	636136	Forest Game Population Dynamics	R. H. Giles	44
	904	636153	Wildlife Management Funds	E. F. Bell	44
	301	636159	Ailanthus Genetics	P. P. Feret	37
	401	636160	Red Oak Steam Effects	G. Ifgu	98
	111a	636174	P. Lambertiana Germination	R. E. Adams	21
	401	636175	Tree Bark Properties	R. E. Martin	104
Washington	107	16	Cloud-Engulfed Forests	D. R. Satterlund	11
State Univ.	301	41	Plantation Christmas Trees	R. W. Dingle	37
	301	1771	Genetics of Multinodalness, Lodgepole	R. W. Dingle	37
	401	1772	Piezoelectric Effect in Wood	R. F. Pellerin	100
	111a	1849	Snow Catch in Crowns	D. R. Satterlund	22
	107	1925	Characteristics of Elk Sedge	B. B. Roche'	11
	512	1929	Vibrational Parameters, Lumber	R. F. Pellerin	108
	401	1942	Structure, Shear Strength, Douglas-Fir	A. F. Noskowiak	101
	111c	2002	Even-Aged Forest Stands	L. V. Pienaar	81
	202	1770	Alder Hypoxolon	J. D. Rogers	73
	903	1969	Forested Watershed Analysis	W. R. Butcher	118
Washington	111a	1	Nitrogen; Growth of Douglas-Fir	S. P. Gessel	22
Univ. of	101	3	Recreational land Uses	G. W. Sharpe	6
	111a	4	Environment; Quality of Wood	J. S. Bethel	22
	111a	6	Ecology, Physiology, Douglas-Fir	D. R. M. Scott	25
	202	8	Fommes Annosus; Management	C. H. Driver	71
	401	9	Surface Properties; Wood	B. S. Bryant	100
	102	12	Fire, Forest Soil	D. W. Cole	6
	401	13	Mathematics; Fiber Assemblages	G. G. Allan	100
	401	15	Problems in Elasticity, Wood	B. A. Jayne	104
	301	16	Genetic Studies; Hardwoods	R. F. Stettler	37
	101	17	Investigation of Forest Soils	F. C. Ugolini	4
	513	19	Forest Products Industries	T. R. Waggener	88
	107	20	Snow-Melt Water	D. D. Wooldridge	11

<i>State</i>	<i>RPA</i>	<i>Proj. No.</i>	<i>Abbreviated Title</i>	<i>Project Leader</i>	<i>Page</i>
Washington Univ. of	109	21	A Coniferous Ecosystem	D. W. Cole	12
	201	22	Bark Beetles	R. I. Gara	66
	512	23	Model for Wood Quality	J. S. Bethel	108
	401	24	Wood Members Deterioration	H. D. Erickson	99
	111b	25	Wildlife Populations, Douglas-Fir	R. D. Taber	52
	903	27	Forest Ecosystems Analysis	J. S. Bethel	118
West Virginia Univ.	301	1	Selection, Valuable Hardwoods	F. C. Cech	37
	401	2	Growth and Density, Hardwoods	J. R. Hamilton	104
	401	3	Sprout Black Cherry Utilization	C. B. Koch	104
	111c	5	Growth and Yield, Hardwoods	D. L. Kulow	81
	102	6	Surface-Mined Lands, Reforestation	R. Lee	6
	904	7	Sonagram Analyses; Game Birds	D. E. Samuel	44
	401	8	Particle Board Composites	J. R. Hamilton	101
Wisconsin Univ. of	202	1264	Oak Wilt	J. E. Kuntz	71
	111a	1350	Metabolic Antitranspirants	T. T. Kozlowski	25
	202	1434	Plantation Root Diseases	R. F. Patton	73
	401	1518	Checks in Wood	H. J. Kubler	104
	303	1571	Sampling Designs; Management	L. G. Arvanitis	84
	111c	1675	Forest Growth Simulation	A. R. Ek	81
	903	1714	Forest Land-Use Allocations	J. D. Brodie	118
	201	1784	Sawfly Anti-feedants	D. M. Benjamin	66
	301	1785	Elm Breeding	D. T. Lester	35
Wyoming Univ. of	111a	880	Biotic Communities	H. G. Fisser	25
	202	928	Diseases of Aspen	W. D. Ross	73
	111b	940	Ecology of Aspen	A. A. Beetle	51
	904	70	Summer Elk Range	A. A. Beetle	44
	111b	71	Park Area Boundaries, Forests	P. C. Singleton	52

Appendix II

INDEX OF PROJECTS

The following index of projects provides abbreviated information on the character of the McIntire-Stennis research program. For the first time, in this report, the RPA classification is given for each project. Thus, it will be possible to visualize more readily the emphases and diversities among the research institutions and in the overall program.

The index summary data reflect changes in the program. The number of projects increased from 503 to 521 from 1970 to 1971, a 4-percent rise. The number of scientists increased 3 percent, from 525 to 539. The number of graduate students engaged in McIntire-Stennis research projects rose 18 percent—401 to 471. An even greater increase occurred in the number of publications issued—405 in 1971 vs. 317 in 1970. It is gratifying to see this 24-percent rise.

Chapter and RPA ¹ subject			Alabama	Auburn Univ.	Alaska	Univ. of	Arizona	Univ. of	Arizona	Northern Univ.	Arkansas	Univ. of	California	Univ. of	California	Humboldt St.	Colorado	State Univ.	Connecticut	Univ. of	Connecticut	Agr. Expt. Sta.	Delaware	Univ. of	Florida	Univ. of	Georgia	Univ. of	Hawaii	Univ. of	Idaho	Univ. of	Illinois	Univ. of	Illinois	SIU	Indiana	Purdue Univ.	Iowa State	Kansas	State Univ.	Kentucky	Univ. of	Louisiana	State Univ.	Louisiana	Tech	Maine	Univ. of	Maryland	Univ. of	Massachusetts	Univ. of	Michigan	Univ. of	Michigan	State Univ.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									

¹ RPA = Research Project Area.

